OCT 14 1924

PRINTED ON THIN PAPER FOR FOREIGN CIRCULATION.

Engineering Library

ENGINEERING:

An Illustrated Weekly Journal.

OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.2.

VOL. CXVIII.—No. 3066.] LONDON: FRIDAY, OCTOBER 3, 1924. [Registered at the General Post Office as a Newspaper.] [PRICE ... 1s. BY FOREIGN POST 1s. 3½d.

Aveling & Porter, Ltd.,
ROCHESTER.
Steam & Crude Oil Road Rollers, &c. 1869

A. G. Mumford, Ltd.,
CULVER STREET WORKS, COLCHESTER.
On Admiralty and War Office Lists.
ENGINES for Torpedo Boats, Yachts, Launches.
BOILER FEED PUMPS.
See advertisement page 19.
PATENT WATER-TUBE BOILERS.
AUTOMATIC FEED REGULATORS.
And Auxiliary Machinery as supplied to the Admiralty. 2179

Dredging Plant
OF ALL DESCRIPTIONS.
FLOATING CRANES. COAL BUNKERING VESSELS.
Werf Conrad, HAARLEM, HOLLAND.
Agents: MARINE WORKS, Ltd., Friars House, 39-41, New Broad St., LONDON, E.C.2.
See half-page Advert. last week and next week. 2087

CRANES. All Types.
GEORGE RUSSELL & CO., LTD., Motherwell. 1867

STEEL TANKS, PIPES, GASHOLDERS, &c.
Thos. Piggott & Co., Limited,
BIRMINGHAM. 1241
See Advertisement last week, page 19.

Spencer-Hopwood & Kirke
PATENT BOILERS 1994
See Page 73.
Sole Makers: SPENCER-BONECOURT, LTD., Parliament Mansions, Victoria St., London, S.W.

Tank Locomotives.
Specification and Workmanship equal to Main Line Locomotives.
R. & W. HAWTHORN, LESLIE & CO. LTD., ENGINEERS, NEWCASTLE-ON-TYNE. 1864

P. & W. MacLellan, Ltd.,
CLUTHA WORKS, GLASGOW.
MANUFACTURERS OF RAILWAY CARRIAGES AND WAGONS OF EVERY DESCRIPTION.
RAILWAY IRONWORK, BRIDGES, ROOFING, &c.
Chief Offices: 129, Trongate, Glasgow. Od 8547
Registered Offices: Clutha House, 10, Princes St., Westminster, S.W.1.

Brett's Patent Lifter Co.
LIMITED.
Hammers, Presses, Furnaces,
COVENTRY. 610

Invincible Gauge Glasses.
BUTTERWORTH BROS., Ltd.,
Newton Heath Glass Works,
Manchester. Od 9753

Patents.—Exhibition Visitors
can obtain information respecting patents, etc., from B. T. KING, Regd. Patent Agent, 146A, Queen Victoria St., E.C.4. For free appointment Wembley Exhibition, 'Phone Central 682. Handbook free.

Fuller, Horsey, Sons & Cassell.
SPECIALISTS
in the
SALE AND VALUATION
of 1834
PLANT AND MACHINERY
and
ENGINEERING WORKS.
11, BILLITER SQUARE, E.C.3.

Iron and Steel
Tubes and Fittings.
Sole Licensees in Great Britain for the manufacture of "Armco" Rust and Corrosion Resisting Iron Tubes. 2257
The Scottish Tube Co., Ltd.
HEAD OFFICE: 34, Robertson Street, Glasgow.
See Advertisement, pages 36 and 38, Sept. 26.

YARROW & CO. (1922), LTD., GLASGOW.
PASSENGER AND CARGO STEAMERS.
SHALLOW DRAFT VESSELS. 2276

Campbells & Hunter, Ltd.
Gear Cutting.
Worm Wheels cut up to 13 ft. diam.
Bevel and Mitre Wheels planed up to 3 ft. diam.
Spur Wheels cut up to 9 ft. diam.
DOLPHIN FOUNDRY, LEEDS. 4547

VOSPER & CO., LTD.,
PORTSMOUTH,
SHIP & LAUNCH BUILDERS, Od 3551
ENGINEERS & BOILER MAKERS.

THE GLASGOW ROLLING STOCK AND PLANT WORKS.
Hurst, Nelson & Co., Ltd.,
Builders of RAILWAY CARRIAGES, WAGONS ELECTRIC CARS, and EVERY OTHER DESCRIPTION OF RAILWAY and TRAMWAY ROLLING STOCK.
Makers of WHEELS and AXLES, RAILWAY PLANT, FORGINGS, SMITH WORK, IRON & BRASS CASTINGS.
PRESSED STEEL WORK OF ALL KINDS. Od3382
Reg. Office and Chief Works: Motherwell. London Office: 32, Great St. Helen's, Bishopsgate, E.C.3.

OIL FUEL APPLIANCES,
Systems
PRESSURE, AIR, STEAM
For Boilers of all types.
KERMODES LIMITED,
36, The Temple, Dale Street, Liverpool.
Naval Outfits a Speciality,
also for Merchant Ships, for Factories, Locomotives, and Industrial Process Furnaces of all kinds.
Supplied to the British and other Governments.
Telephone No.: Central 2832.
Telegrams: "Warmth." 4078

Locomotives Tank Engines
designed and constructed by
MANNING, WARDLE AND COMPANY, LIMITED,
Boyne Engine Works, Leeds. Od 2487
See their Illus. Advertisement, page 95, last week.

Gearing of all Descriptions.
GEAR WHEELS up to 10 ft. diameter.
FLY ROPE and SPUR DRIVING WHEELS up to 28 ft. diameter.
BRICK and CLAYWORKING MACHINERY of all kinds.
ENGINES:—"Uniflow," "Corliss," or Drop Valve.
CLAYTON, GOODFELLOW & CO., LTD., Blackburn. 1249

R. Y. Pickering & Co., Ltd.
(Established 1864.)
BUILDERS of RAILWAY CARRIAGES & WAGONS
MAKERS of WHEELS and AXLES of all kinds.
Chief Offices and Works:
WISHAW, SCOTLAND.
London Office: Od 8353
10, IDDESLEIGH HOUSE, WESTMINSTER, S.W.1.

ON ADMIRALTY LIST.
John Kirkaldy, Ltd.,
London Office: 101, LEADENHALL ST., E.C.3.
Works: BURNT MILL, near HARLOW, ESSEX.
Makers of
Evaporating and Distilling Plants.
Refrigerating and Ice-making Machinery.
Feed Water Heaters.
Evaporators.
Fresh Water Distillers.
Main Feed Pumps.
Combined Circulating and Air Pumps.
Auxiliary Surface Condensers,
&c., &c. 2327

Rosser and Russell, Ltd.,
MECHANICAL ENGINEERS,
QUEEN'S WHARF, HAMMERSMITH, W.
Undertake SPECIAL MACHINE WORK of any description.
WELL EQUIPPED SHOP.
LATHE WORK up to 10 ft. diameter.
'Phone: Hammersmith 31, 967. 9211

John Bellamy, Limited,
MILLWALL, LONDON, E. 1216
GENERAL CONSTRUCTIONAL ENGINEERS.
Boilers, Tanks, & Mooring Buoys
STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETED STEAM AND VENTILATING PIPES, HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.

IRON & STEEL
Tubes AND Fittings AND Steel Plates.
STEWARTS AND LLOYDS, Ltd.
GLASGOW - BIRMINGHAM - LONDON.
See Advertisement, page 32 1872

Peter Brotherhood Ltd.,
PETERBOROUGH.
STEAM ENGINES AND TURBINES.
GAS AND OIL ENGINES.
AIR COMPRESSORS.
REFRIGERATING PLANT. 1475
See Advertisement, page 55, Sept. 26.

MACHINE CUT
Gears.
Spurs, Bevels.
Spiral, Worm and Worm Wheels.
HIGHFIELD GEAR CUTTING CO.
(Dept. E.),
Huddersfield. 1645

The Glasgow Railway Engineering Company,
GOVAN, GLASGOW. LTD.,
London Office—12, Victoria Street, S.W.
MANUFACTURERS OF
RAILWAY CARRIAGE, WAGON & TRAMWAY WHEELS & AXLES.
CARRIAGE & WAGON IRONWORK, also CAST-STEEL AXLE BOXES. 1943

For Sale, Motor-Driven Air COMPRESSOR, by Bellies & Morcom. 1000 cubic ft. per min. 100 lbs. pressure, with 500 volt D.C. motor.—THE PHŒNIX ELECTRICAL CO., LTD., 17, Oswald Street, Glasgow. D 291

Steel Screwed and Socketed PIPING.
FOR IMMEDIATE DELIVERY.

6 in.	-	-	30,000 feet.
8 in.	-	-	9,360 "
10 in.	-	-	15,000 "
12 in.	-	-	14,000 "

Full particulars from
THOS. W. WARD LTD.,
ALBION WORKS, SHEFFIELD.
London Works, Silvertown, E.16. F 21

Yorkshire Engine Co., Ltd.,
Meadow Hall Works, Sheffield,
Railway, Colliery, Mining and General Engineers, are PREPARED to UNDERTAKE the MANUFACTURE of NEW SPECIALITIES suited to their plant and tools.
No financing of patents. Only serious business entertained.
Address confidential enquiries to the SECRETARY.

RAILWAY AND TRAMWAY ROLLING STOCK.
Hurst, Nelson & Co., Ltd.,
THE GLASGOW ROLLING STOCK AND PLANT WORKS,
MOTHERWELL. Od 3383

E. J. Davis, M.I.Mech.E.,
Gas Engines Inspected, Tested and Reported upon. Over 25 years' experience. Tel.: Maryland 1736 & 1737. Wire: "Rapidising, London." —Great Eastern Road, Stratford, E.15. 1794

Laboratory Equipment for Metallography.
The "DAVON" Pat. Super-Microscope.
"Capable of remarkable work"—*Dr. Rogers.*
"Ease of manipulation in high power work." Moderate cost. Brochure "C" with photographic specimens free from:—
F. DAVIDSON & Co., 29, Gt. Portland St., London, W.1.

Royles Limited,
ENGINEERS, IRLAM, MANCHESTER.
FEED WATER HEATERS, CALORIFIERS, EVAPORATORS, CONDENSERS, AIR HEATERS, } ROW'S PATENTS,
Merrill's Patent TWIN STRAINERS for Pump Suctions.
SYPHONIA STEAM TRAPS, REDUCING VALVES.
High-class GUNMETAL STEAM FITTINGS.
WATER SOFTENING and FILTERING. 5723

YARROW & CO. (1922), LTD., GLASGOW.
LAND AND MARINE
YARROW BOILERS. 2277

Matthew Paul & Co., Ltd.
LEVENFORD WORKS, Dumbarton. 2213
See Full Page Advt., page 60, Sept. 12.

Forgings.
Walter Somers, Limited,
HALESOWEN. 7116

Taylor & Challen Presses
For Production of SHEET METAL WORK, COINAGE, CARTRIDGES AND GUNPOWDER.
Foundry, Works and Showrooms: BIRMINGHAM.
See Advert., page 52, Sept. 19. 8195

Head, Wrightson & Co.,
LIMITED.
See Advertisement page 32. 2402

Railway Switches and Crossings.
T. SUMMERSON & SONS, LIMITED,
DARLINGTON. 2006

For Your Repairs or any
SPECIAL MACHINERY, try
THOMAS HUNT & SONS,
Albion Ironworks,
Bridge Road West, Battersea, S.W.11.
Est. 1854. 2348

PROPELLERS
AND PROPULSION PROBLEMS.
Special designs only.
"Circulation Theory."
Akimoff Propeller Company,
PHILADELPHIA, U.S.A. 2349

Telegrams: "Epa," London.
Telephone: 7424 Central.
E. P. Alexander & Son.
CHARTERED PATENT AGENTS,
306, High Holborn, London, W.C.1. 585
PATENTS. DESIGNS. TRADE MARKS.

Electric Cranes.
Traversers.
Transporters.
Lifts.
S. H. HEYWOOD & Co., LTD.,
Reddish. 1357

The Manchester Steam Users' ASSOCIATION.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, Mount Street, Manchester.

Chief Engineer: C. E. Stromeyer, M.I.C.E.

Founded 1854 by Sir William Fairbairn.

Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 2005

Engineering Tuition:—B.Sc.

(First Hons. Eng.) assisted by M.Inst C.E. and staff gives Expert and Individual Tuition for all exams., including Inst.C.E., Inst.M. & Co.E., Inst.Mech.E., and Lond. Univ. Degree (Matric, Inter. and Final). Correspondence Courses or personal tuition in drawing office.—Apply, E. G. Longbottom, B.Sc., 3, 5 and 7, Old Queen Street, Westminster. S.W.1. Tel: Vic. 761. F 105

Correspondence Courses for

Inst.Civil Engrs., Inst.Mech.E., London Univ. (Matric., Inter., B.Sc.), and All Engineering Examinations personally conducted by Mr. Trevor W. Phillips, B.Sc. (Honours), Assoc. M.Inst.C.E., M.R.S.I., F.R.S.A., etc. Also Day Tuition in Office. Excellent results at all Exams. Courses may commence at any time, and all Students receive individual tuition.—For full particulars apply to 8/11, Trafford Chambers, 58, South John Street, Liverpool. 1993

Engineering Salesmanship

and Sales Management.—Write for brochure describing our special Course of Training for posts of unlimited scope in this lucrative field.—Director, Institute of Engineering Salesmanship, 333, Oxford Road, Manchester. 2282

Engineering Drawing.—

Special Postal Course in Engineering Drafting. Enrol now. Fee Three Guineas for the complete course. Also day tuition in Office by qualified teacher. Established in 1835.—Percy Pitman, M.I.Mech.E., 25, Victoria Street, London, S.W.1. 2297

TENDERS.

EGYPTIAN STATE RAILWAYS.

Supplies are Required of:—

FLAT BOTTOM RAILS.
BOLTS AND NUTS for Fishplates.
COACH SCREWS.
STEEL FISHPLATES and ANGLED STOPS.
SADDLES.

Specification can be obtained from the INSPECTING ENGINEER, Egyptian and Sudan Governments, Queen Anne's Chambers, Westminster, London, S.W.1, at the price of 8s. each copy for each class of material.

Adjudication will take place in Cairo for the first two items on the 27th October and the last three items on the 29th October. G 31

NORTHUMBERLAND COUNTY COUNCIL.

PROPOSED FERRO-CONCRETE BRIDGE OVER THE TWEED AT BERWICK.

Tenders are Hereby Invited

for the CONSTRUCTION of the above BRIDGE, consisting of Approaches, and Arches up to 360 ft. in span.

Specifications, Bills of Quantities, Forms and Conditions of Tender and Contract may be obtained from and the drawings inspected at the offices of Messrs. L. G. Mouchel & Partners, 33, Victoria Street, Westminster, S.W.1, and Trinity Buildings, 25, New Bridge Street, Newcastle-on-Tyne, upon the payment of a deposit of £100. This amount will be returned to the Tenderer if his Tender is a *bona fide* one, and has not been withdrawn prior to the definite acceptance of a Tender by the County Council.

Tenders will only be considered from firms with an extensive experience of this class of work. Tenders on the official form and accompanied by a fully priced Bill of Quantities and statement of the Contractors' experience must be submitted and enclosed in a sealed envelope endorsed "Tender for Berwick Bridge," to the undersigned, and must reach them not later than Twelve Noon on Monday, the 27th day of October, 1924.

The County Council does not bind itself to accept the lowest or any Tender.

By Order,
L. G. MOUCHEL & PARTNERS, LTD.,
Civil Engineers.

Trinity Buildings,
25, New Bridge Street.
Newcastle-on-Tyne. F 983

CITY OF BIRMINGHAM ELECTRIC SUPPLY DEPARTMENT.

A.C. Generating Plant for SALE.

The Undermentioned PLANT, installed at the Corporation Electric Generating Station, Summer Lane, Birmingham, is FOR DISPOSAL:—

One Bellis Triple-expansion, Three-cylinder ENGINE, direct coupled to 1500 K.V.A. Three-phase Alternator, 5000 volts, 25 periods, 166 r.p.m., by Dick Kerr & Co., Ltd. (combined as one unit), with Bellis EXHAUST STEAM TURBINE, direct coupled to a Westinghouse 1500 K.V.A. Three-phase Alternator, 1500 r.p.m., complete with Condenser, Motor-driven Edwards' Air Pumps, Interconnecting Piping, Ladders and Gangways.

The Plant, which will be released in January, 1925, was installed in 1912, is in first-class condition and can be inspected or seen on load by appointment.

The dismantling and removal of the plant to be carried out by the purchaser at his own expense and risk.

The use of an overhead travelling crane will be allowed free, the purchaser to accept all responsibility for any damage done to buildings or other plant in the Station.

Fuller particulars and permits to inspect can be obtained on application to the undersigned, to whom all offers should be addressed.

Offers should be sent in not later than 13th October, 1924.

E. J. JENNINGS,
Secretary.

14, Dale End,
Birmingham.
September, 1924. G 12

ADMINISTRATIVE COUNTY OF LONDON.

VICTORIA EMBANKMENT SUBWAY.

The London County Council invites

Tenders for the Construction

of TWO STAIRWAYS to the Existing Subway under the Victoria Embankment, near Westminster Bridge.

Persons desiring to submit Tenders may obtain the Drawings, Specification, Form of Tender, etc., on application to the Chief Engineer at the Old County Hall, Spring Gardens, S.W.1, upon payment of £3 which will be returnable only if the Tenderer shall have sent in a *bona fide* Tender, and shall not have withdrawn the same. Full particulars of the work may be obtained on personal application, and the Drawings, Specification and other contract documents may be inspected before the payment of the fee.

No Tender received after Four p.m. on Monday, 13th October, 1924, will be considered.

The Council does not bind itself to accept the lowest or any Tender.

JAMES BIRD,
Clerk to the London County Council. G 25

ABERDEEN CORPORATION WATER WORKS.

TORRY MAIN—CAST IRON PIPES AND PIPE LAYING.

The Town Council of Aberdeen are prepared to receive

Tenders for:—

(1) The SUPPLY of half a mile of 9 inch diameter Cement-lined CAST IRON PIPES and SPECIALS.
(2) The LAYING of the above PIPES.

The Drawings may be inspected, and Specification, Schedule of Quantities, and Form of Tender obtained on and after 2nd October, 1924.

For each Specification a deposit of Two Pounds Sterling will be required, which sum will be returned to the Tenderer provided that he shall have sent in a *bona fide* Tender, and shall not have withdrawn the same.

The employment of labour shall be in accordance with the conditions of the Unemployment Grants Committee.

Tenders, on the Forms prescribed and enclosed in securely sealed envelopes, endorsed "Tender for PIPING," are to be addressed to the Undersigned. No Tender delivered after Nine a.m. on 16th October, 1924, will be considered.

The Town Council do not bind themselves to accept the lowest or any Tender.

GEORGE MITCHELL,
M.Inst.C.E., F.R.San.I.,
Water Engineer.

Water Engineer's Office,
41½, Union Street, Aberdeen.
30th September, 1924. G 30

BURGH OF FINDOCHTY.

FINDOCHTY HARBOUR EXTENSION.

The Town Council of Findochty are prepared to receive

Tenders for the Extension of

the Harbour, comprising the Excavation of the Harbour Bed and the construction of a Mass Concrete Jetty, Mass and Reinforced Concrete Quay Walls, and relative works.

Copies of the Specification, Conditions, Schedule, Form of Tender, and the Drawings may be inspected at the offices of Messrs. Henderson & Nicol, Chartered Civil Engineers, 21, Bridge Street, Aberdeen, or at the office of the subscriber.

Contractors desirous of Tendering may obtain the necessary documents from Messrs. Henderson and Nicol on payment of the sum of Two Guineas, which sum will be returned upon receipt of a *bona fide* Tender together with the documents.

The Engineers' representative will be in attendance at the site of the works from 10.30 a.m. on Wednesday 8th October, 1924, to meet intending offerers.

Sealed Tenders to be lodged with the Subscriber on or before the 27th October, 1924.

The Town Council do not bind themselves to accept the lowest or any Tender.

WILLIAM SMITH,
Solicitor,
12, East Church Street,
Buckie.
Town Clerk. G 1

PORT OF BRISTOL.

RECONSTRUCTION of SWING BRIDGE, JUNCTION LOCK, CUMBERLAND BASIN, BRISTOL.

The Docks Committee invite

Tenders for the Reconstruction

of the SWING BRIDGE over the Junction Lock, Cumberland Basin, Bristol. The work in the contract is to include foundations, abutments, steelwork, and opening and closing machinery. Building Contractors will be allowed to sublet the steelwork and the machinery. Bridge Construction Contractors will be allowed to sublet the building work and the machinery. Tenders must, however, include for the whole of the work.

On and after Monday the 29th day of September, 1924, copies of the Specification etc., can be obtained from the undersigned on production of a receipt to the undersigned showing that a deposit of £5 has been paid to the *Bristol Docks Committee, to whom all cheques must be sent and made payable.* The deposit will be returned to *bona fide* tenderers after the receipt of the tender with all the prescribed documents and drawings.

Tenders must be enclosed in a sealed envelope endorsed "Tender for Reconstruction of Swing Bridge, Cumberland Basin, Bristol," and addressed to the General Manager and Secretary of the Docks Committee, 19, Queen Square, Bristol, and must be delivered to him accompanied by all the prescribed documents and drawings before Ten a.m. on Monday the 27th day of October, 1924.

The Docks Committee do not bind themselves to accept the lowest or any Tender.

THOMAS A. PRACE,
Chief Engineer.

Chief Engineer's Office,
Avonmouth Dock, Bristol.
24th September, 1924. F 976

The Director-General,

India Store Department, Branch No. 16, Belvedere Road, Lambeth, S.E.1, REQUIRES:—

1. RAILWAY CARRIAGE WHEEL LATHE, Motor-driven.
2. BODY IRONWORK and FITTINGS for Railway Carriages.

Tenders due on the 21st October, 1924, for No. 1, and on the 28th October, 1924, for No. 2.

Tender Forms obtainable from above. G 38

APPOINTMENTS OPEN.

Assistant Works Manager

WANTED for modern Works, near London, manufacturing high grade electrical apparatus and telegraph instruments.

Must have had experience in the class of work and be able to control staff and workmen, and be familiar with up-to-date methods of manufacture and have had a good scientific training.

Address, stating age, experience and salary required, F 980, Offices of Engineering.

Works Manager Wanted, for

Small Engineering Works in South of England, employing about 60 hands, general engineering repairs, fitting shop, iron and brass foundry, forge, etc. Must be experienced Mechanical Engineer, good organizer and time supervisor, accustomed to estimating.—Address, stating full particulars, experience, age and salary, G 34, Offices of Engineering.

Wanted, Assistant to Head

of Publicity Department, age 25-30. Good education and engineering training; thoroughly experienced in copy writing for advertisements and technical catalogues, photography and block making and all branches of advertising.—Address, giving fullest particulars of training, experience, firms worked for, and wage required, G 13, Offices of Engineering.

Wanted, Foundry Organiser

for Eastern Counties, capable of getting the best out of Foundry Moulding Machinery. Send experience.—Address, G 42, Offices of Engineering.

Pig Iron.—Direct Representation.

—English representative required to travel England and Continent, Good salary and Commission. Fluent French and Mechanical Training imperative. Position offers scope, permanency and advancement for energetic capable man with personality.

Full particulars, experience, connections, age and salary in strict confidence.—Address, G 36, Offices of Engineering.

Wanted, First-class Man to

take complete charge of Manipulating Department of large Tube Works. None but experienced men need apply.—Address, stating age, particulars of experience and salary required, F 991, Offices of Engineering.

The Royal Air Force

requires engine driver fitters, power station engineers and wireless operators. Age limits:—18 to 30. Pay from 24s. 6d. to 38s. 6d. per week, on enlistment, and all found. Allowance for wife and children to men 26 and over.—Write, stating age, or call:—Inspector of Recruiting, R.A.F., 4, Henrietta Street, Covent Garden, W.C.2. F 993

Large Firm of Electrical

Engineers manufacturing highly specialised dynamos, motors, switchgear, and accessories, requires the services of an electrical engineer as Assistant to the Chief of their research Laboratory. First-class training and experience are essential; previous experience in the design department of a firm of good standing is an additional recommendation. Good salary and opportunities of advancement offered to a man with initiative, energy and the above qualifications.—Applications should be addressed, F 981, Offices of Engineering.

Engineer Wanted, Hampshire

district, take charge first-class engineering shop equipped modern tools. Must be thoroughly capable producing all kinds metal fittings, mostly of small dimensions, to very fine limits. Essential should be good organiser and able to handle men to ensure quick production.—Address, fullest particulars, G 32, Offices of Engineering.

Civil Engineering Assistant.—

A Firm of Consulting Engineers requires at once, a Competent ENGINEERING ASSISTANT, with a large experience in the design and execution of Modern Sewerage and Sewage Disposal, and Water Supply Works.—Replies (which will be treated in confidence), giving experience, salary required, age, etc., to be addressed, G 17, Offices of Engineering.

Assistant Engineers

(THREE) REQUIRED by the PUBLIC WORKS DEPARTMENT, FEDERATED MALAY STATES, for four years' service with possible permanency. Salary $400 a month rising to $800 by annual increments of $25, plus a temporary non-pensionable allowance of 10% for bachelors and 20% for married men. The exchange value of the dollar in sterling is at present fixed by the Government at 2s. 4d., but its purchasing power in Malaya is considerably less than that of 2s. 4d. in the United Kingdom. Free passages provided. Candidates age, 26 to 35, preferably unmarried, must have received a good theoretical training preferably at a University or an Engineering College recognised by the Institution of Civil Engineers, or have completed articles with a Civil Engineer of good standing, and have passed the examination for Associate Membership of the Institution of Civil Engineers. Possession of an Engineering or Science degree preferred. In addition to pupilage must have had at least one year's practical experience in the design and execution of works of some considerable magnitude. A knowledge of modern road making and maintenance is desirable.—Apply at once by letter, giving brief details of qualifications and experience, and stating age whether married or single, to THE CROWN AGENTS FOR THE COLONIES, 4, Millbank, Westminster, S.W.1, quoting clearly at head of application M/13142. G 10

Experienced Sales Representative

required by leading firm in Lift Trade. Sound Engineering and Commercial training essential.—Address, in first instance, giving full details of qualifications, experience, age, and salary, G 37, Offices of Engineering.

Wanted, for Cuba, Shift

ENGINEER. Age about 30, for large Power Station. Capable carrying out all repairs on steam turbines and auxiliary plant. Man with Marine Certificate preferred.—Write, with full particulars of experience, etc., to B. R., c/o J. W. Vickers & Co., Ltd., 5, Nicholas Lane, E.C.4. F 996

Wanted, Engineer for Foreign

Sales Department. Well educated, good practical and technical training, also selling experience. French and commercial experience abroad essential.—Address, giving full particulars of age, experience and salary required, G 14, Offices of Engineering.

Assistants (Three) Required

by the Government of Hong Kong for service in the Architectural Office of the Public Works Department for a period of three years with possible permanency. Salary £460, rising by annual increments of £20 to £500 a year, and thence (if appointment is made permanent) to £950 a year, payable locally in dollars at the Government rate of exchange which is at present fixed at 2s. to the dollar. In addition a strictly temporary exchange allowance of 20% of salary is at present paid, and thus at the present time the annual salary in dollars will be $5520 a year. The current rate of exchange being now about 2s. 5d. to the dollar, the sterling equivalent of $5,520 is accordingly about £667 a year. No income tax payable. Candidates, unmarried, 25 to 32 years of age, must be duly qualified Architects' Assistants and Associates of the R.I.B.A., should be experienced in design and the preparation of working drawings, details and specifications, and have some knowledge of quantities. Experience in the design and erection of steel framed buildings, and a working knowledge of reinforced concrete is desirable.—Apply at once by letter, stating age, qualifications and experience, to THE CROWN AGENTS FOR THE COLONIES, 4, Millbank, Westminster, S.W.1, quoting M/12919. G 39

MUNICIPALITY OF COLOMBO, CEYLON.

APPOINTMENT OF AN ASSISTANT ENGINEER.

The Colombo Municipal Council requires the

Services of an Assistant

ENGINEER.

Candidates must have passed the A.M.I.C.E., or other equivalent examination. Preference will be given to those who have had experience in all branches of Municipal Engineering, and is unmarried candidates.

The salary attached to the post is Rs. 7,200 a year, rising by annual increments of Rs. 360 (beginning from a year after the date of appointment), to Rs. 10,800, together with a travelling allowance of Rs. 1,200 a year provided that a motor car is kept for the purpose.

The selected candidate will be required to enter into an agreement to serve the Council for a period of three years. At the end of the three years, if the Officer has carried out his duties to the satisfaction of the Council, he will be appointed to the permanent staff, with leave and pension rights according to Council's regulations.

Medical examination as to fitness for service in the East is required.

Free passage to Colombo by first-class intermediate or second-class mail steamer, will be provided with half-pay during the voyage out.

Application forms and further details can be obtained from the Council's London Agents, Messrs. JOHN POOK & CO., 68, Fenchurch Street, London, to whom candidates should forward their applications before 15th October, 1924.

THE TOWN HALL,
Colombo, 26th August, 1924. F 946

Draughtsman Required,

thoroughly experienced in Aerial Ropeways. Write fully details of experience, age and salary.—Address, F 982, Offices of Engineering.

Draughtsman—Midlands.

Machine Tool or Textile estimating experience an advantage.—Address, F 989, Offices of Engineering.

Chief Draughtsman, to Take

charge of staff of twelve; capable organiser and fully experienced in quick and accurate estimating for structural and chemical plant. Give full details of past experience, age, salary required. —Address, F 988, Offices of Engineering.

Temporary Leading Draughtsman

required with general engineering experience, to take charge of a small drawing office. Also a TEMPORARY JUNIOR. State age, experience, and salary expected.—Address, F 987, Offices of Engineering.

Draughtsman, Junior, Wanted

by Firm in Midlands. Must have good knowledge of Electric Overhead Cranes, Wharf Cranes, etc.—Address, stating experience and salary required, G 7, Offices of Engineering.

Experienced Draughtsman for

dust removal schemes and preferably with knowledge of fan application.—Age, salary and experience to Box 213, c/o Mather & Crowther, Ltd., 10, New Bridge Street, E.C.4. F 997

Wanted, Experienced

DRAUGHTSMAN used to hydraulic cranes and structural work.—Apply, by letter only, stating age, experience and salary required, to THE HYDRAULIC ENGINEERING CO., LTD., Chester. G 6

Draughtsman Required

immediately, thoroughly experienced in design of water tube boilers and pulverised fuel plants. Permanent and progressive position for suitable applicant. State age, salary, and past experience.—Address, G 3, Offices of Engineering.

THE PROPORTIONING OF IMPULSE BLADES AND NOZZLES.

By GERALD STONEY, D.Sc., F.R.S.

IN proportioning one-row impulse blades and nozzles there are a large number of factors to be taken into account, many of which have doubtful values. It therefore becomes a matter of importance to consider the effect of each factor separately, and to investigate at the same time the influence that an error in the assumed values of these factors has on the final result. It may be mentioned that since the effect of these factors is more marked in two and three-row blading than in one row, the correct assumption of values for them becomes of even greater importance. In one-row blading the exit angles of the nozzle and blade are fixed by the designer, who then, by assuming various coefficients, finds the ratio of the nozzle height to the blade height. In many cases it is considered desirable to have a certain amount of reaction; that is, to have part of the heat drop in the blades, as this appears to improve the efficiency obtainable. If, however, there is too much reaction, the pressure drop across the blades causes loss by spilling and also end pressure on the turbine rotor. The amount of reaction which gives the best results is very

Fig.1. PROPORTIONING OF IMPULSE BLADING.

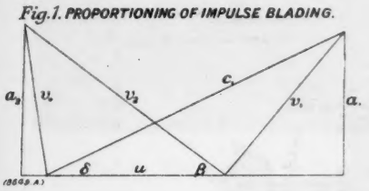


Fig.2.

IMPULSE NOZZLE.

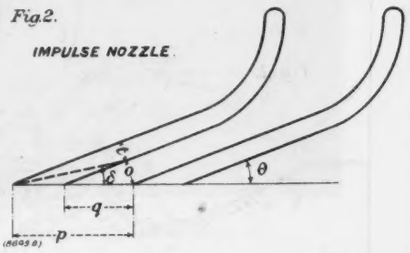
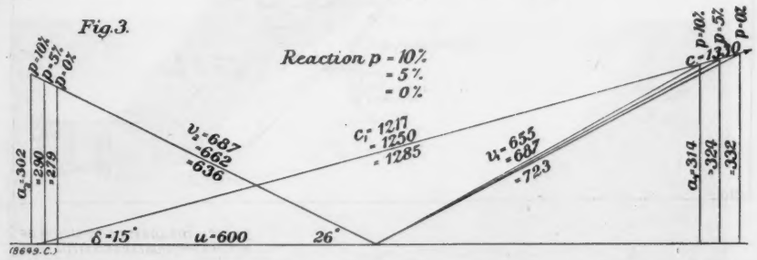


Fig.3.



doubtful, and the actual amount obtained depends entirely on the correctness of the assumptions made.

The ratio of nozzle height to blade height at exit or $\frac{h_1}{h_2}$ is primarily the ratio of the axial velocities, $\frac{a_2}{a_1}$, of the steam from the velocity diagram (Fig. 1). A correction, however, has to be made for the expansion of the steam due to drop of pressure in the blade, and rise of temperature due to friction in passing round the blade. This correction is, however, generally small.

Let H = heat drop per stage in B.Th.U.
K = carry-over factor.
ρ = reaction or proportion of the total heat drop in the blades.
ϕ = velocity coefficient of the nozzle.
ψ = velocity coefficient of the blades.
u = blade velocity, feet per second.
$c = \sqrt{2\,g\,J\,H}$.
c_1 = actual velocity of exit from the nozzle.
$a = \frac{u}{c}$ = nominal velocity ratio.
δ = angle of exit of the steam from the nozzle.
β = angle of exit of the steam from the blade.
$C_1^2 = \phi^2\,K\,(1-\rho)\,c^2$.
$v_1^2 = c_1^2 + u^2 - 2\,u\,c_1 \cos\delta$.
$v_2^2 = \psi^2\,(v_1^2 + 2\,g\,J\,\rho\,K\,H)$.
$a_1 = c_1 \sin\delta$.
$a_2 = v_2 \sin\beta$.

$$\therefore \frac{a_2^2}{a_1^2} = \psi^2 \frac{\sin^2\beta}{\sin^2\delta}\left\{1 + \left(\frac{u}{c_1}\right)^2 - 2\,\frac{u}{c_1}\cos\delta + \rho\,K\,\frac{c^2}{c_1^2}\right\}$$

$$= \psi^2 \frac{\sin^2\beta}{\sin^2\delta}\left\{1 + \frac{a^2}{\phi^2\,K\,(1-\rho)} - \frac{2\,a\cos\delta}{\phi\,\sqrt{K\,(1-\rho)}} + \frac{\rho}{\phi^2\,(1-\rho)}\right\} \quad . \quad . \quad . \quad (1)$$

Of the various factors in this equation, the value of the velocity coefficient of the nozzle ϕ is fairly well known from the work of the Nozzles Committee of the Institution of Mechanical Engineers* and other investigators. For the velocities usual in practice, *i.e.*, from 800 ft. to 1,600 ft. per second, its value is $0{\cdot}95 \pm 0{\cdot}01$ in well-proportioned nozzles.

The Committee also found that the efficiency of nozzles with thick and thin partition plates is practically the same provided the outlet edge of the plates was well chamfered. It also seems that the exit angle of the steam is, for average conditions, the angle whose sine is $\frac{o}{p}$ or $\frac{o}{p} = \sin\delta$ as shown in Fig. 2, and not the nominal angle of the nozzle, which is $\frac{o}{q} = \sin\theta$. This is generally true to about $\pm 1\frac{1}{2}°$, but a closer estimate can be made by an examination of the curves given in the reports referred to above for nozzles such as were tested, and it is not a difficult matter to make tests on the nozzles actually to be used by the methods developed by the Nozzles Committee, so that it should be possible to determine this angle to, say, $\pm \frac{1}{2}°$, which only makes a small error in the height ratio by equation (1).

Little is known generally about the angle of exit of the steam from the blades, but it is probable that if the thickness coefficient of the blade is taken into account, the angle of exit β is given correctly for all practical purposes.

A further uncertain factor is the value of the blade coefficient ψ, which depends on the state of the surface, the shape of the blades and steam passage, the angle through which the steam is turned, the velocity of the steam and its condition, *i.e.*, whether it is wet or superheated. Other factors may also come in. Tests on this velocity coefficient are extremely difficult to carry out, more especially as there are such a large number of variables, but for average conditions ψ may be taken as $0{\cdot}88 \pm 0{\cdot}05$. Since the height ratio varies as ψ, there is here an uncertainty of about 5 per cent. to 6 per cent.

Another loss is due to the spilling of the steam so that the whole of the steam leaving the nozzle does not pass through the blades. Little is known about this loss, but it is generally small unless there is too much reaction or drop of pressure across the blades, and unless there is too much clearance between the nozzle and the blade. It is therefore important that the reaction should not exceed a certain amount depending on the design. A point to be noticed is that generally the amount of clearance between the nozzle and the blade has a considerable effect on the efficiency. Various forms of baffle have been proposed to reduce this loss, but few have come into general use.

A source of gain is the carry-over K from the preceding stage. How much of the carry-over velocity is actually utilised is doubtful since experiments on it are most difficult to carry out, but probably some 50 per cent. to 75 per cent. of the energy of carry-over is utilised when there is complete admission and less with partial admission.

The effect on the reaction ρ of the various uncertain factors ψ, β and δ in equation (1) with a given height ratio $\frac{a_2}{a_1}$ can only be easily seen by taking examples.

If H = 35·4 B.Th.U., K = 1·03 or HK = 36·4, u = 600 ft. per second, $a = 0{\cdot}45$, $\phi = 0{\cdot}95$, $\psi = 0{\cdot}88$, $\delta = 15$ deg. and $\beta = 26$ deg., a diagram is obtained as in Fig. 3. The ratio $\frac{a_2}{a_1}$ determined from the diagram has to be corrected for the increase in volume of the steam as it passes round the blade due to friction and pressure drop in order to get the height ratio $\frac{h_1}{h_2}$.

Various methods can be used to estimate this increase of volume, which is generally small, and the following is an approximate method.

The heat developed due to friction will be $\Delta H = \frac{v_1^2\,(1-\psi^2)}{2\,g\,J}$, and, for no reaction, this is $\frac{723^2\,(1-0{\cdot}88^2)}{50{,}000} = 2{\cdot}36$ B.Th.U. Taking the specific heat of steam as 0·5 the rise of temperature will be 4·7 deg. F. and if the steam temperature is 400 deg. F., the increase of volume will be 0·55 per cent.

In the case of 5 per cent. reaction it will be 0·5 per cent.

The increase due to pressure is $\frac{\Delta V}{V} = \frac{J\,\Delta H}{\gamma\,B}$ where ΔH is the heat drop in the blade and B is the homogeneous head of the steam. $\Delta H = \rho\,K\,H = 0{\cdot}05 \times 36{\cdot}4 = 1{\cdot}82$ B.Th.U. and taking B = 70,000 and $\gamma = 1{\cdot}3$

$$\frac{\Delta V}{V} = \frac{778 \times 1{\cdot}82}{1{\cdot}3 \times 70{,}000} = 1{\cdot}6 \text{ per cent.}$$

so the total increase of volume is 1·6 plus 0·5 equals 2·1 per cent. Similarly, for 10 per cent. reaction the increase of volume will be 3·6 per cent. The following table is thus obtained:—

Reaction ρ Per Cent.	a_2	a_1	$\frac{a_1}{a_2}$	$\frac{\Delta V}{V}$ Per Cent.	$\frac{h_2}{h_1}$
0	279	332	1.19	0.5	1.20
5	290	324	1.12	2.1	1.14
10	302	314	1.04	3.6	1.08

It is thus seen that 10 per cent. reaction means a change in the height ratio of 10 per cent. or that any error in ψ, sin β or sin δ will make approximately a similar error in the amount of reaction.

Other examples show that this is, generally speaking, practically correct. It follows that the amount of reaction actually obtained depends on correct values being assumed for the various coefficients, and on account of the uncertainty of these, the actual amount of reaction obtained in practice is very doubtful. As the maximum normal amount of reaction allowable in 1-row impulse blading is of the order of 10 per cent., it is easy to see the importance of this. It is evident that the amount of reaction will tend to increase when the blading is allowed to become corroded or dirty, and thus excessive spilling of the steam may occur in addition to other losses.

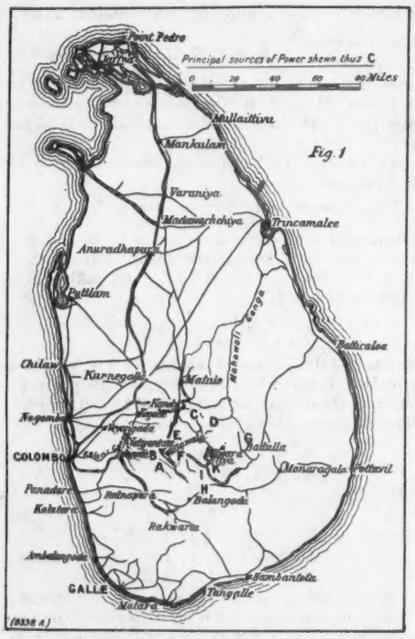
* Proc. I.M.E. January and March, 1923, and July, 1924. ENGINEERING, vol. cxv, page 377, and vol. cxvii, page 681.

THE ABERDEEN-LAXAPANA HYDRO-ELECTRIC SCHEME, CEYLON.

ENGINEERS familiar with the interior of Ceylon can hardly have failed to be impressed by the apparent suitability of the favoured island for hydro-electric development. The country is not sufficiently extensive for spectacular schemes to be possible, but streams of various sizes thread their way through much of it in all directions. The northern part is unfavourable, consisting mainly of low plains, sometimes slightly undulating, but often for great regions unbroken except by occasional isolated hills which may be nothing more than single rocks, or boulders of gigantic size. The characteristics

of the southern part of the island are, however, altogether different. Here, behind a fringe of low-lying land running along the seaboard, a very abrupt rise is made to an upland region broken by mountains and valleys, with extensive plains at high elevations. This district extends for about 4,000 sq. miles, and its elevation above the coast lands varies between 2,000 and 7,000 ft. On the north-east side this region falls away gradually to the lower levels, but on the south-west side it is bounded by precipitous cliffs and very steep slopes, so that in the past access to the interior was extremely difficult. It was for this reason that, although invading Powers often overran the seaboard, and hordes from India swept over the northern plains, the kings of Kandy succeeded in maintaining the interior region intact till quite a recent date. The approaches were most jealously guarded, and comparatively few of the strangers who ventured into this part of the interior were ever permitted to depart from it while they lived.

The region was only finally pacified after the construction of the first of the two roads which for



long alone rendered it approachable on the west. This road, constructed by Major Dawson, utilised the Kadugannawa Pass, with a summit level 1,698 ft. above the sea, by which the railway now penetrates to Kandy and beyond. The second road further to the south follows the Kelani Valley and runs up the Ginigathena Pass, with a summit 2,168 ft. above sea level, reaching the high lands at Nawalapitiya. There are at other points steep paths, making a limited degree of communication feasible. The highest mountain of Ceylon in this interior region is Pidurutalagala (8,296 ft.), though Adam's Peak is more prominent and better known. In the Pidurutalagala district are several of the upland plains to which we have referred, but the most extensive of these are the Horton Plains, distant about 15 miles and at an elevation about 1,000 ft. higher, or 7,000 ft. or so above the sea level. Above these plains rise two of Ceylon's highest mountains, Kirigalpota (7,836 ft.) and Totapella (7,746 ft.), while from their edge to the south-west one realises how inaccessible this region still is from this side. The plains end in sheer rock precipices on the edge of which one can look perpendicularly down for over 1,200 ft., beyond which the fall is so rapid that the whole 7,000 ft. drop to practically sea level is accomplished in a few miles.

The most important rivers of Ceylon rise in the districts to which we have referred. The Mahaweli-ganga, flowing generally north-east and finding the sea at Trincomalee, is fed from the Pidurutalagala and the Horton Plain regions. The much shorter Kelani-ganga flows mainly west to Colombo, rising also in the Horton Plains and receiving contributions from the Adam's Peak district. Both these rivers and their tributaries offer possibilities as regards hydro-electric development. Stream gauging has been carried out by the Public Works Department for a number of years, and in 1917 more complete hydrometric surveys were embarked upon to determine the capabilities of development of the more promising schemes. As a result the sites marked upon the accompanying map, Fig. 1, were fixed upon as suitable from an engineering point of view, the estimated power for each being as follows:—

	H.p.
(A) Aberdeen Falls } Laxapana Falls }	200,000
(B) Kitulgala Rapids	50,000
(C) Haragama	36,000
(D) Teldeniya	160,000
(E) Ulapane	40,000
(F) St. Claire Falls	100,000
(G) Dunhinda Falls	18,800
(H) Behilul-oya	8,000
(I) Elgin Falls...	8,000
(K) Parawella Falls	4,000

Fig. 2.

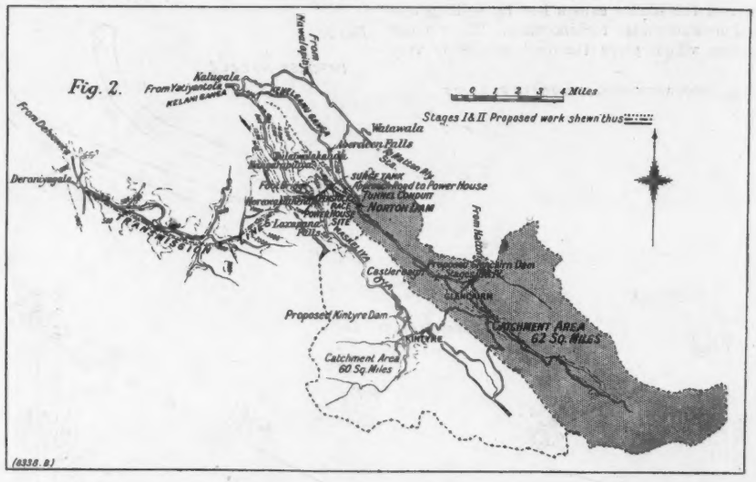
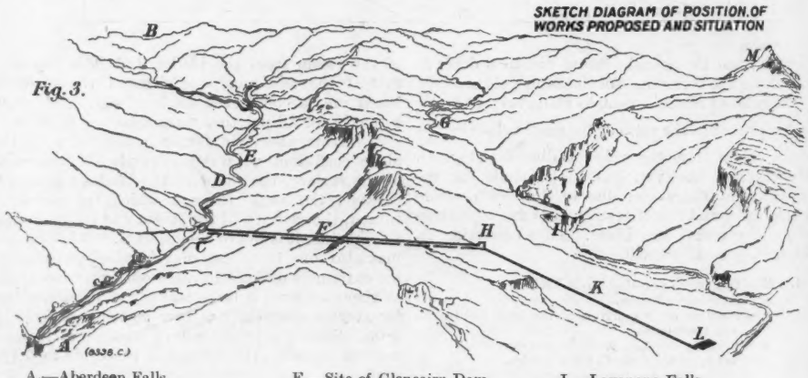


Fig. 3.



A.—Aberdeen Falls.
B.—Horton Plains.
C.—Site of Norton Bridge Dam.
D.—Aberdeen Valley.
E.—Site of Glencairn Dam.
F.—Tunnel through ridge.
G.—Site of Kintyre Dam.
H.—Surge Tank and Foreboy.
I.—Laxapana Falls.
K.—Pipe lines.
L.—Horawalathena Power House.
M.—Adam's Peak.

Of these Nos. C, D, E, F, G and K are on the Mahaweli-ganga. A and B are on the Kelani-ganga and its tributaries. The first and most important scheme, A, is concerned with two rivers, the Kehelgamu-ganga and the Maskeliya-oya, which, joining together, form the Kelani-ganga. It is this scheme to which attention has first been paid. It was originally mooted while Lieut.-Col. T. H. Chapman, O.B.E., M.Inst.C.E., was Director of Public Works for Ceylon. On his retirement last year the matter was followed up by his successor, Mr. J. Strachan, M.Inst.C.E., assisted by Mr. D. J. Wimalasurendra, and, having been reported upon by Messrs. Preece, Cardew and Rider, was recently laid before, and the first stage adopted by, the Legislative Council of the country. The first stage is estimated to cost Rs. 10,710,000, the sum to be provided, in the first instance, as necessary by Treasury Bills. Work is to be put in hand at once, and advantage taken of the Home Government's offer to defray three-fourths of the interest on money borrowed for the purpose for the first five years for which interest is payable, provided that materials, &c., are purchased in the United Kingdom. The region is central and lends itself to comparatively easy development. It is within easy transmission distance of Colombo and is surrounded by tea and rubber-planting districts.

The scheme is designed to utilise eventually the full flow of the Kehelgamu-ganga (or -oya) catchment and that of the Maskeliya-oya, as shown by Fig. 2. As the former will probably suffice for some years, details for the development of the latter have not yet been worked out. Both these oyas (streams) rise in the neighbourhood of Horton Plains and run in adjacent and parallel valleys, with considerable fall, in a north-westerly direction, meeting ultimately at an elevation of 700 ft. above sea level. The scheme takes its name from the Aberdeen Falls on the Kehelgamu-oya, and the Laxapana Falls on the Maskeliya-oya, both of which will be found marked in Fig. 2. The main features are an intake and regulating dam at Norton Bridge, in the Aberdeen Valley, a storage dam at Glencairn, with further storage eventually higher up. The Maskeliya-oya would be controlled by a dam at Kintyre, with other possibilities in the higher reaches for ultimate development. The power-house is planned to be placed in the Maskeliya-oya valley below the Laxapana Falls, the supply from the Kehelgamu-oya being led to it by a tunnel through the intervening ridge.

The catchment area of the Kehelgamu-oya above the dam at Norton Bridge is 62 sq. miles, and that of the Maskeliya-oya above the Kintyre dam site 60 miles. The rainfall over both catchments is well distributed and above 100 in. a year, while the

dry season seldom exceeds a month in duration. Quite a number of rainfall-gauging stations have been established in both catchment areas for many years, and their records have been made use of to supplement the stream gaugings taken during the past six years. A fairly accurate estimate of the run-off under all conditions has thus been made possible. At the Norton Bridge weir the minimum dry-weather flow of the Kehelgamu-oya is approximately 100 cusecs. The gauging point on the Kehelgamu-oya at the site of the proposed Norton Bridge dam is shown in Fig. 5.

FIG. 4. THE VALLEYS OF THE KEHELGAMU-OYA AND MASKELIYA-OYA.

FIG. 5. THE NORTON BRIDGE SITE OF THE DAM ON THE KEHELGAMU-OYA.

The scheme which has now been decided upon is a variation of the one put forward by Lieut.-Col. T. H. Chapman in 1921. In the main the characteristics are identical. The present arrangement will cost less to carry out and will be cheaper to operate, but 450 ft. of head are sacrificed, the head now being 1,500 ft. in lieu of the 1,950 ft. of the earlier project. The new scheme is admittedly the more economical development of the two supplies involved. As now adopted the undertaking provides for an intake dam and regulating reservoir of 30 million gallons capacity at Norton Bridge, involving a structure about 90 ft. high provided with a spillway. The pressure tunnel from this intake through the ridge separating the two valleys will be 8,100 ft. in length and of a sectional area of 63 sq. ft. This will terminate at a surge chamber and forebay. For the first section of the scheme only one 65-in. to 45-in. pipe line will be laid to the power-house below, the length of line being 5,250 ft. The sites for these several components of the project are shown in Fig. 2. An excellent idea of the project may also be obtained from the key sketch Fig. 3, while Fig. 4 gives a good impression of the nature of the country of the two valleys. In Fig. 3 Adam's Peak is shown on the right, while Horton Plains are located in the far distance. At present the supplies of the left-hand valley only are being developed.

The power station at Horawalatpena, on the east bank of the Maskeliya-oya, will be built for a first instalment of three turbo-generator sets each of 5,650 kw. This will develop only one-third of the possible output of the Aberdeen Valley, or one-sixth of the ultimate output of the two sources combined, based on a load factor of 50 per cent. As the demand grows it is proposed as a first expansion to add a fourth generating set, after which further load would be met by the construction of the Glencairn dam, which would be 100 ft. high, impounding about 2,000 million cub. ft. of water. An additional pipe line and extension of the power station would also be involved. To utilise the full resources of the Aberdeen Valley a further dam could be erected and two additional pipe lines installed. With the project advanced as far as the completion of the Glencairn dam, the scheme would have an output of about 50,000 kw. It is stated that the demand already in sight amounts to this figure, so that it is considered that the success of the first instalment decided upon is well assured.

Transmission to Colombo, a distance of 42 miles, is to be at 88,000 volts, three-phase, 50 cycles, by duplicate pole line. The line will cross the Maskeliya-oya at the power-house and pass through Avissawella, at the mouth of the Kelani Valley. A sub-station will be erected at Welikade, on the outskirts of Colombo. From this the first transmission system will extend north to Negombo, on the coast, north-east to Veyangoda, and south along the coast to Panadure. Subsequent extensions will be developed as occasion arises from Veyangoda to Polgahawela, and direct from the power station to Kandy and beyond, and to Ratnapura and beyond, as well as up-country to Talawakela and Nanu-oya. The load for the early stage of the scheme is expected to be derived from tram ways and lighting in Colombo, factories and mills in Colombo, and small users. In later stages, in addition to the extension of supply in these directions and to the gem mining district of Ratnapura, the possibility of electrifying parts of the railways is considered. Since the rise from Polgahawela to Kandy and again further up country from Hatton to Pattipola, where the main line reaches its highest point at 6,620 ft. above sea level, involves very steep gradients, electrification in this area would seem to present a very attractive aspect, though this is not discussed at all in the official reports bearing on the Aberdeen-Laxapana scheme.

The cost of the first stage, placed at Rs. 10,710,000, or about 714,000*l.* (at Rs. 15 to the 1*l.*), is for 10,000 kw. delivered at Colombo, with 16,800 kw. plant installed. This works out at 40*l.* per kilowatt of installed plant. The early items would include the Norton Bridge intake works, tunnel and forebay, which have been designed and estimated for a capacity sufficient for the development of the full resources of the Kehelgamu-oya, and are therefore necessarily somewhat out of proportion as regards cost to the remainder of the preliminary installation.

BRITISH EMPIRE EXHIBITION: RAILWAY MATERIAL.—VII.

IN our first article of this series we gave on page 539, of our last volume, a detailed description of the handsomely-furnished car built by the Metropolitan Carriage, Wagon & Finance Company, Birmingham, for H.M. the King of Egypt, for use on the Egyptian State Railways. On that occasion our article was so complete that there is comparatively little to add to it in explanation of the views and drawings of the coach, which we publish this week on pages 476 and 477 and on our two-page Plate LI. A general view of the vehicle is given in Fig. 163, while Fig. 164 shows the interior of the saloon, the partition door being open and thus permitting a view of the private bureau beyond. Beyond the latter again is situated the bedroom, which, in turn, communicates with the bathroom, of which we give a view in Fig. 165. On our two-page engraving, Figs. 166 to 168 give elevations and plan of the vehicle; in the plan, Fig. 167, the foregoing references to the interior arrangements may be followed. Since the furnishing of the compartments is mostly of the usual movable type, constructional drawings of the saloon, &c., do not show features of any peculiar interest. The arrangement of the bathroom is shown in Figs. 169 to 173.

The exterior of the coach presents a very neat appearance, the sides being finished with one long panel below the waist rail, and the whole body being painted in cream colour picked out with gold lining. The centre of the panels is adorned with the coat of arms of the King of Egypt. The general appearance of the vehicle is much enhanced by the liberal and symmetrical disposition of the sidelights which are all 4 ft. wide. The roof is double, the space between the sun roof carlines and those of the main roof being 6 in., while 4-in. openings between the two are arranged all round to ensure thorough ventilation of the space enclosed between them. Access to the coach is by means of doors on either side at

SALOON FOR H.M. THE KING OF EGYPT; BRITISH EMPIRE EXHIBITION.

CONSTRUCTED BY THE METROPOLITAN CARRIAGE, WAGON AND FINANCE COMPANY, LIMITED, ENGINEERS, BIRMINGHAM.

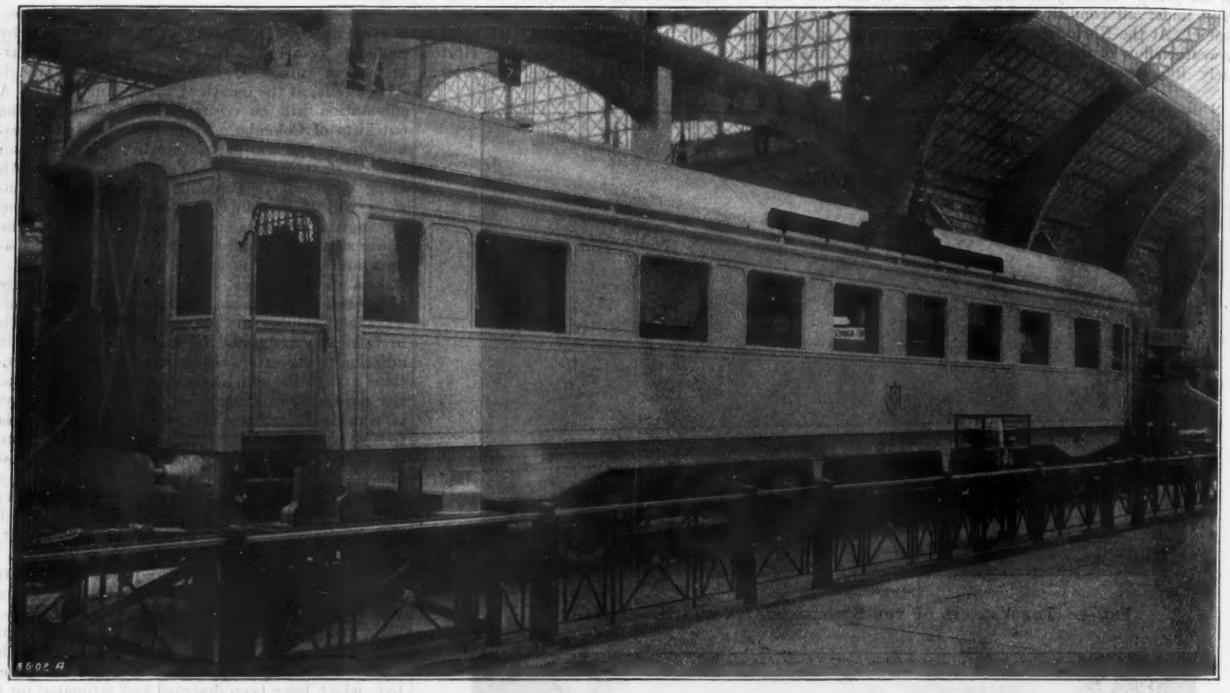


Fig. 163. The Saloon in the Palace of Engineering.

Fig. 164. View of Interior.

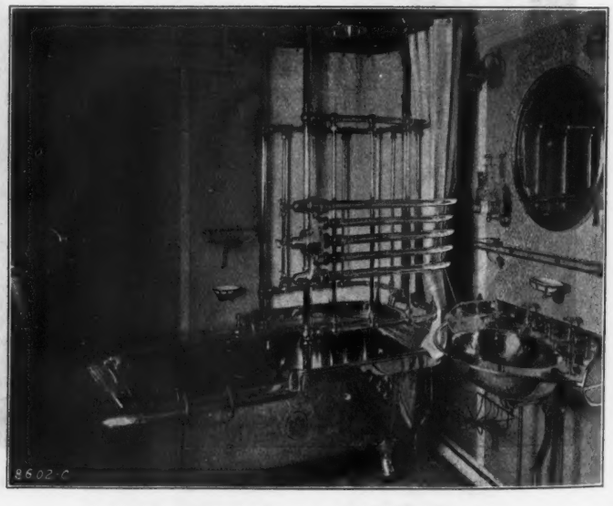


Fig. 165. The Bathroom.

each end, with steps, the bottom two of which are arranged to slide inwards so as to clear the loading gauge.

The interior of the coach is very handsomely finished, as will be gathered from the typical view we give in Fig. 164. The mouldings and carving are dignified and not over elaborate, a point of great moment in connection with keeping railway vehicles clean and in good order in such a country as Egypt. The saloon, as mentioned in our former article, is decorated with quartered panels of satin wood, carved pilasters and enrichments, with oxydised silver fittings. The bureau leading out of it is finished in Adams style, the panelling being of mahogany inlaid with satinwood. While the upholstery of the saloon is in blue, that of the adjoining bureau is green, the fittings in the latter room being of mercurial gold. The bedroom is perhaps the most ornate part of the coach, the style being Louis XVI. This compartment is finished in white enamel, with carved work and enrichments in gold. The chair coverings are of old gold, and the curtains are of the same, while the carpet is of dark olive green. The bedstead and metallic fittings are of mercurial gold.

The bathroom is probably one of the best ever arranged on a railway coach. The illustrations Figs. 169 to 173, Plate LI, give a good idea of the conveniences provided, while the photograph reproduced in Fig. 165, above, depicts in a convincing manner the high class of the fittings installed. The general appearance of the room is excellent, the sides being finished in Wedgwood blue, with white mouldings, &c. The floor is laid with mosaic tiling, drained towards the centre. The bath is silver plated, as is also the table lavatory basin. Bath and basin are fitted with both hot and cold water, the former having shower and needle sprays. The oval mirror is framed in silver, and the towel rails are of glass in silvered brackets. The spray end of the bath is provided with a waterproof curtain.

Details of the underframe are given in the drawings, Figs. 174 to 180, Plate LI. The principal points in the construction of this have been already noted in our previous article, and need hardly be repeated. We may, however, draw attention to the deep flitch plates fitted to the solebars over the bogies. The frame is trussed with four rods extended out to the headstocks in all cases, carried over the bogie cross bearers in the form of flat bars. The bogies, which are illustrated in Figs. 181 to

BOGIE FOR EGYPTIAN ROYAL SALOON; BRITISH EMPIRE EXHIBITION.

CONSTRUCTED BY THE METROPOLITAN CARRIAGE, WAGON AND FINANCE COMPANY, LIMITED, ENGINEERS, BIRMINGHAM.

Fig. 181.

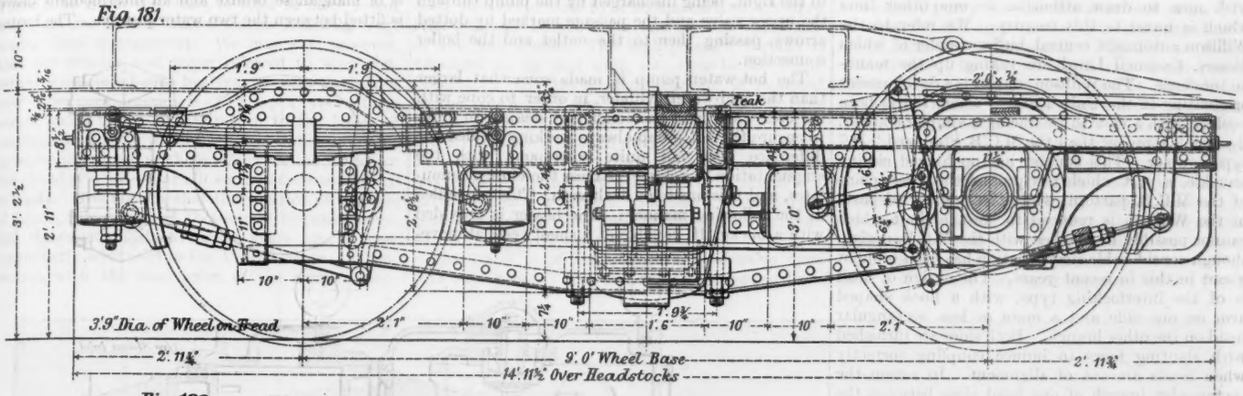


Fig. 182.

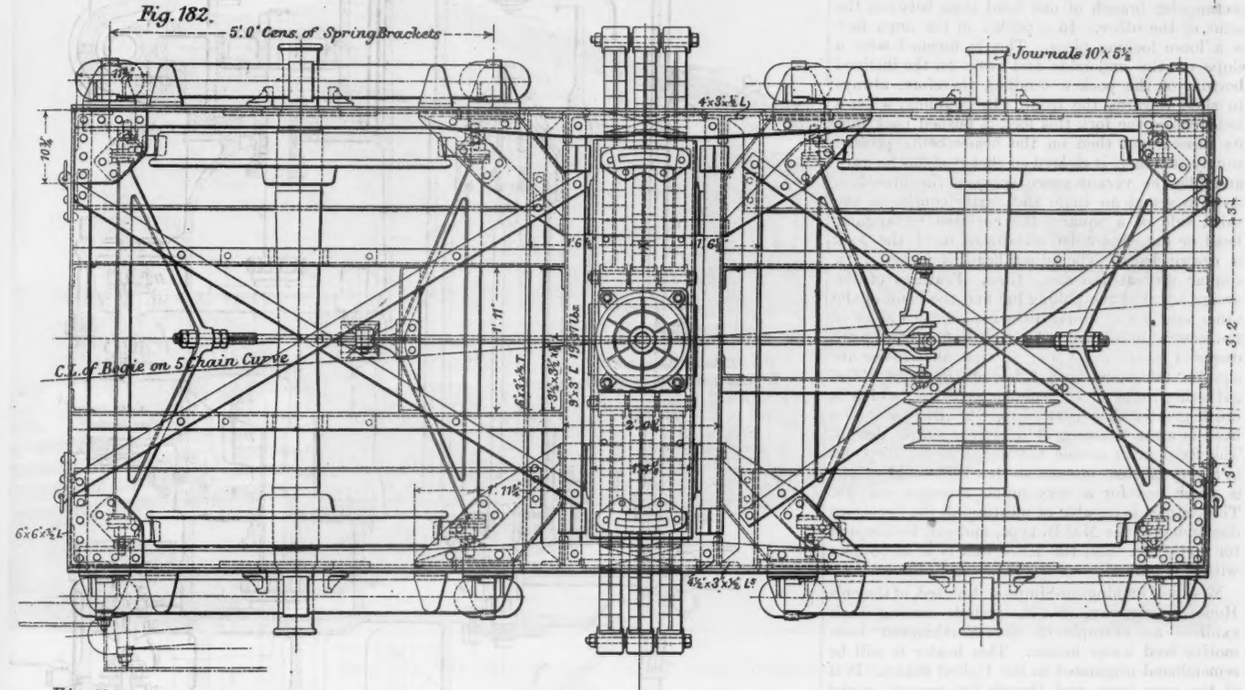


Fig. 183.

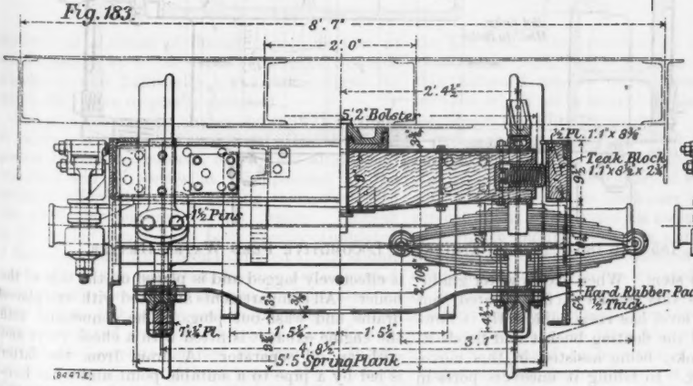
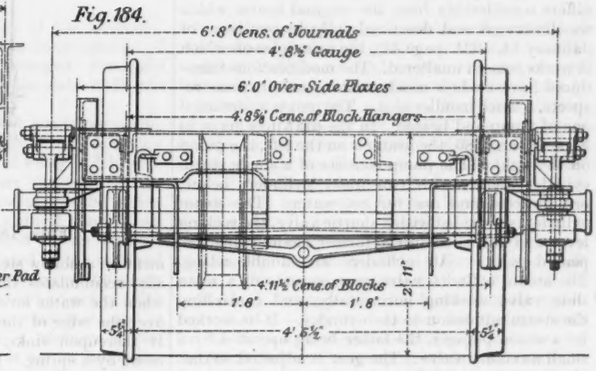


Fig. 184.



184 above, possess interesting features. The side frames are of ½-in. plate reinforced with angles at the top and bottom edges, while between the transoms and axle-box guides they are pierced by large openings flanged inwards. The bogie is very well sprung. The bolster is carried by six elliptical springs in two groups of three. Long semi-elliptical springs are provided over the axle boxes, and the spring hangers for these have rubber springs. The hangers have ball sockets. The spring plank is suspended by two-point parallel hangers. The bolster is of teak, plated on the top and sides with $\frac{7}{16}$-in. steel. The transoms are of channel, with flanges facing inwards, and the inside fitted with teak block 8½ in. deep by 2¾ in. thick. Rubbing plates are provided on both these and the bolster. Between the transoms the side frames have filling pieces of teak measuring 1 ft. 1 in. by 8½ in. by 2¾ in., covered on the inside with a ½-in. rubbing plate. In each end of the bolster is a pocket containing a spring plunger to control side movement.

The coach is altogether a very fine example of the high-class vehicles which builders of this

country are able to turn out, and which have won for them so good a reputation abroad.

In previous articles we have made mention of a number of exhibits on the stand of Messrs. Cammell Laird and Co., Ltd., of Sheffield. We wish now to draw attention to one other item which is novel to this country. We refer to the Willison automatic central buffer coupler of which Messrs. Cammell Laird are taking up the manufacture here. The Willison coupler is a development originating in the United States where it has been evolved with a view to producing a simpler coupler, if possible stronger than the M.C.B. Standard "D" type coupler. This coupler has no hinged closing knuckle, a part which has proved the weak point of the M.C.B. pattern, while the number of parts in the Willison is reduced to two, a limit which cannot possibly be reached with the M.C.B. design, though considerable simplification has been brought about in this in recent years. The design of head is of the interlocking type, with a hook shaped arm on one side and a more or less rectangular head on the other branch. Both sides are furnished with slanting faces to induce coupling correctly when heads are out of alignment. In action the rectangular branch of one head slips between the arms of the other. In a pocket in the inner face is a loose locking piece. This is finished with a slope on the underside and rests on the inclined bottom of the pocket, tending, therefore, always to slide towards the front. In coupling, when a head enters the fork this lock is pushed back into its recess, and then on the heads being pressed snugly together, is cleared so that it slides forward and fills the vacant space between the branches. As it is set at an angle and partly completes the third side of a square, the enclosed rectangular head or lug cannot be withdrawn until the lock is drawn back. The other head is locked in a similar way at the same time. Features of the design are that the pulling lug and the hook of the other arm are at equal distances on both sides of the centre line, while the two buffing faces are disposed in the same way, so that all stresses are equally taken on both sides of the head. The gathering range of the coupler is 10 in., which is much greater than that of the M.C.B. type. The head is a steel casting of relatively simple design. The fixed arms enable the metal to be disposed in a very efficient manner so that the actual weight is much less for a very much stronger coupler. The coupler is capable of meeting all the functions demanded of the M.C.B. type, and can be adapted for transition from the screw link type of coupler with side buffers.

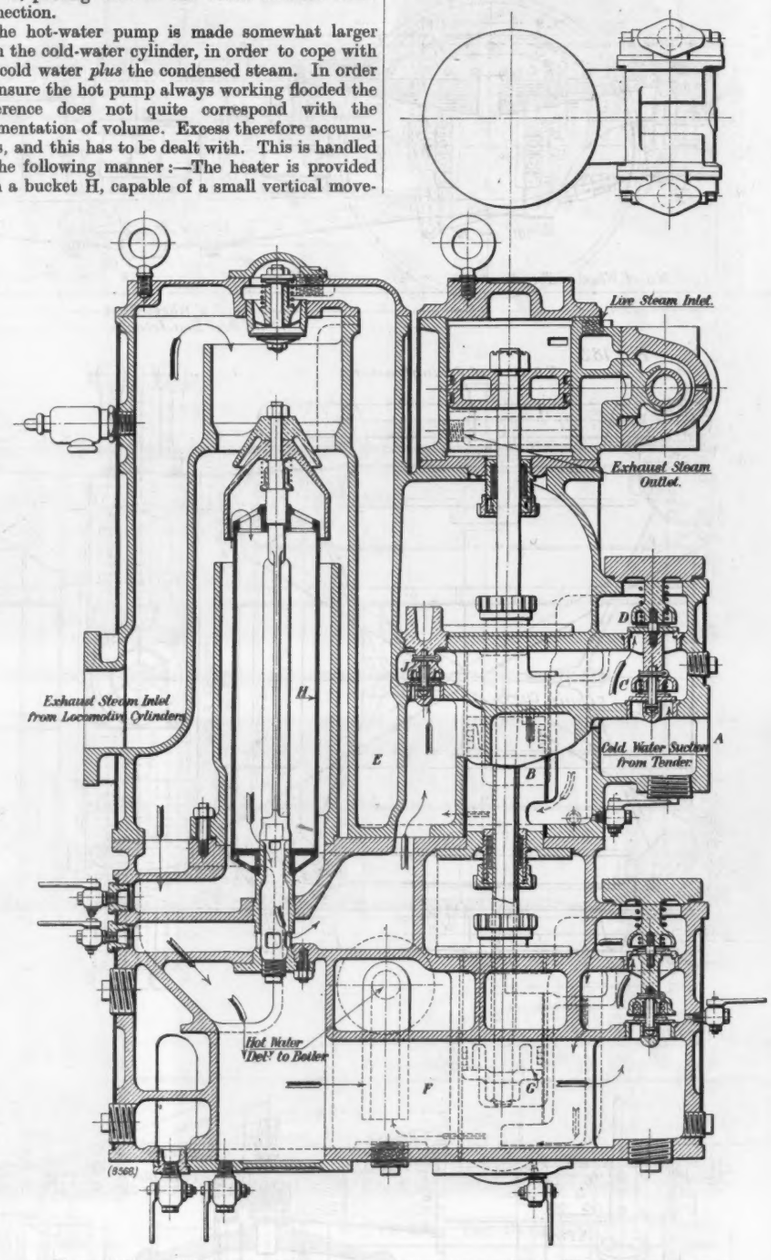
Messrs. Worthington-Simpson, Limited, of Queen's House, Kingsway, W.C.2, include among their exhibits an example of the Worthington locomotive feed water heater. This heater it will be remembered originated in the United States. It is of the open type, and though the present model differs considerably from the original heater which we illustrated and described fully in our issue of January 14, 1921 (page 42), the principles on which it works remain unaltered. The modifications introduced have made a much neater, and in some respects, a much handier unit. The unit is a combined one of pump and heater. In the drawings given in Figs. 185 and 186, the heater is on the left, the pump on the right. The pump consists of a single steam cylinder above, with two water cylinders below, one for cold and one for hot water. The steam cylinder is provided with a shuttle valve, the rocking lever and valve rod in the former model being dispensed with. All cylinders are double-acting. The steam cylinder valve gear consists of a main slide valve working horizontally, and controlling the steam admission to the cylinder. It is worked by a steam plunger, the latter being operated by a small auxiliary valve. The gear is adjusted so that the pump runs at full stroke under all conditions.

Water enters the cold-water (centre) cylinder B from the suction A, through the valve C, being discharged through the valve D. From here it follows the path of the dotted arrows into the space E, from which it is passed into the heater through the spring-controlled valve shown in the heater head. On entering the heater, it is sprayed over baffles, and at this stage comes in contact with exhaust steam from the engine cylinders. The water and condensed steam pass down to the bottom of the heater F, where they accumulate. From this reservoir supplies are drawn by the hot-water pump G (shown dotted) through the lower of the valves to the right, being discharged by the pump through the upper valve and the passage marked by dotted arrows, passing then to the outlet and the boiler connection.

The hot-water pump is made somewhat larger than the cold-water cylinder, in order to cope with the cold water *plus* the condensed steam. In order to ensure the hot pump always working flooded the difference does not quite correspond with the augmentation of volume. Excess therefore accumulates, and this has to be dealt with. This is handled in the following manner:—The heater is provided with a bucket H, capable of a small vertical movement on a hollow stem. When excess water gradually accumulates this bucket is first floated, but when the water level has risen sufficiently it flows over the edge of the floating bucket and floods it. It thereupon sinks, being assisted in this movement by a spring. In falling it uncovers ports in the hollow stem, and this allows the water in the bucket to drain off to a compartment in connection with the small suction valve J. This is in communication with the cold-water pump, and so long as excess water is available, some of it is drawn in at each stroke by this pump, in conjunction with the cold-water supply from the tender, which is correspondingly reduced. When the water is drawn off the bucket is floated again.

As regards construction the unit is of high grade cast iron. The hot and cold barrels are fitted with gun-metal liners. The steam piston is of cast iron; the pump pistons are of bronze fitted with Rockhard water piston packing rings. The piston rod is of manganese bronze and an intermediate sleeve is fitted between the two water pistons. The heater is effectively lagged and is placed on the side of the boiler. All compartments are fitted with well placed drains and wash-out plugs. The connection with the engine exhaust is fitted with a check valve and with an oil separator. A drain from the latter is led by a pipe to a suitable point under the locomotive. Two eye-bolts are provided in the top of the unit for slinging.

The amount of the exhaust steam utilised in the heater and returned to the boiler as feed is about 15 per cent., and the direct and indirect advantages of this are numerous. Apart from fuel economy and additional capacity of the locomotive, the scale forming characteristics of the feed are reduced to this extent and the tender capacity is virtually



FIGS. 185 AND 186. THE WORTHINGTON LOCOMOTIVE FEED WATER HEATER.

increased in the same degree. The general questions of feed water heating and its influence on economy and on the ability of a locomotive to handle increased loads were fully discussed in these columns some thirteen years ago, and in a paper read before the Institution of Mechanical Engineers in 1913. There is no need, therefore, to refer to more recent developments in the United States following very similar lines of argument. We may say, however, that the articles and paper referred to were concerned with closed type heaters, whereas the heater now under consideration is of the open type, a form which, owing to the actual return to the boiler of condensate in the form of feed, has claims superior, in some directions, to those which can be made for the closed system, which allows the condensate to go to waste. It is notable that the question of increase of power, which was so thoroughly discussed here, and shown to exist, so many years ago, is now consistently advanced in the United States in connection with the renovation of the smaller locomotives, as a means of bringing such engines at small expense up to the capacity required by loads which are now habitually heavier than those for which they were originally designed.

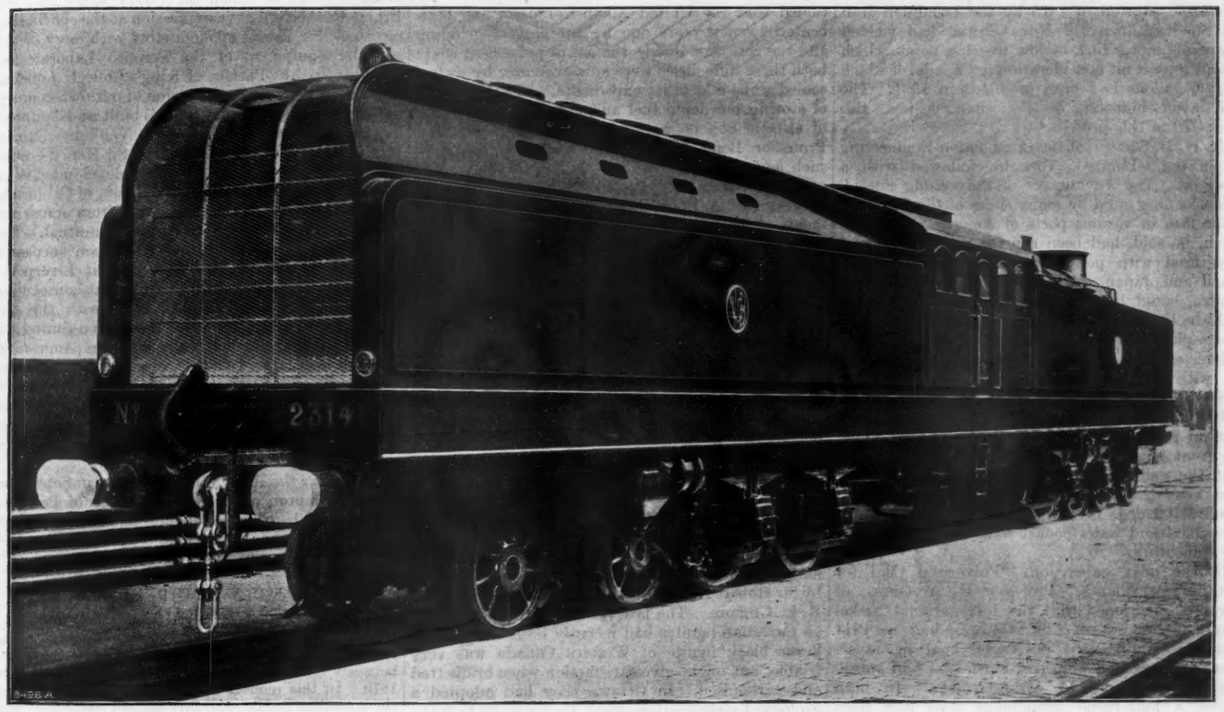


Fig. 187. The Reid-MacLeod Geared Steam Turbine Locomotive.

The greatest novelty among the railway exhibits is undoubtedly the experimental Reid-MacLeod geared turbine locomotive, but we are afraid that engineers will be somewhat disappointed at the facilities afforded for acquainting themselves with the particular features of this design. Interest in the engine would have been greatly stimulated if drawings could have been exhibited at the stand, since many of the important features are concealed from outside view. The engine is illustrated in Figs. 187 to 190, above and on page 488. It has been constructed and is shown by the North British Locomotive Company Limited, of Glasgow. As will be seen, the engine is without tender, the whole of the steam plant being supported by a long rigid frame carried by two compound bogie units. The main frame is bellied in the centre between the bogies. On it at the trailing end is arranged the steam boiler, fitted with forced draught fan and superheater. The front end of the main frame accommodates condensing plant housed within a steel plate casing. This end of the locomotive is well shown in Fig. 187.

Each power unit has eight wheels, four being arranged in a bogie, the others being geared driving wheels. The bogie pivot is in each case at the outward end of the unit, and coincides with the pivot connecting the unit and the main girder framing carrying the steam plant. The driving wheels of each unit are driven by a steam turbine arranged longitudinally at the inner end on the upper side of the unit frame. The high-pressure turbine is arranged on the rear unit, *i.e.*, close to the steam generator; the low-pressure turbine is mounted at the rear end of the front unit. Large flexible pipes connect the two units. Power is transmitted to the driving axles through double reduction gearing. The shaft from the turbine is taken to a gear box situated between the axles where one set of reduction gears is housed. The shaft of the larger gears terminates fore and aft in bevels in gear with other bevels on the axles.

The boiler is of the standard locomotive type with superheater. The feed water is supplied from the hot well. The condenser is of the air-cooled evaporation type, consisting of a large number of thin flattened copper tubes arranged vertically between which air is caused to circulate while the machine is travelling forwards.

Across the open front end of the condenser casing are placed a number of pipes fitted with spraying nozzles, and from these a spray of water is delivered and carried on to the condenser elements by the current of air. This supply is maintained by means of a rotary pump, while the natural flow of air through the condenser is assisted by an induced draught turbine-driven fan situated at the rear end of the condensing plant. An air pump of the steam ejector intercooler type is provided to extract the non-condensible gases from the condenser, and is specially arranged to maintain a vacuum in the condenser when the locomotive is not in operation. The condensate is extracted from the condenser by means of a rotary pump in conjunction with the boiler-feed pump, and is passed through the air pump intercooler to the hot well. Before being delivered to the boiler it is passed through a feed heater, the latter serving to condense the exhaust from the auxiliaries.

The two views, Figs. 189 and 190, of the interior of the cab, situated in the centre of the locomotive, show some of the parts to which we have referred above. Fig. 189, which is of the fireman's end of the cab, shows on the left-hand side the Weir feed pump, and under the window the controls for the lubrication of the condenser auxiliaries and the water spray. On the right-hand side is a forced lubrication pump for the turbines and gears. In the centre of this figure is the boiler head fitted with forced draught arrangement. Fig. 190 is of the driver's end. In the centre of this is the steam turbine driving the induced draught fan for the condensing plant. On the right hand is the hand-wheel for the brake. On the left hand are the Westinghouse and vacuum brake driver's-valves (the engine being dual fitted), turbine steam control and reversing wheel. The Westinghouse pump is mounted at the rear end of the engine, attached to the inner side of one of the side tanks, which at this end extend for some distance beyond the smoke-box.

All bearings are force-lubricated, and the oil for these and for the gearing is supplied by the pump referred to above, the closed system being continuous and embracing suitable cooling arrangements. The auxiliary turbines are under automatic control, with lubrication arranged independently for each unit.

In addition to this machine, the North British Locomotive Company are exhibiting a number of models, including one of a large 4-6-2 type passenger locomotive for the French State Railways, a 4-6-0 type of the Egyptian State Railways, and a 2-8-0 type freight locomotive for the New South Wales Government Railways. Another model is of a modified Fairlie engine which the company is now building for the South African Government Railways. This is a large engine with a 2-6-2 + 2-6-2 type wheel arrangement. A further model represents the 4-6-6-4 type of electric locomotives built for the Imperial Government Railways of Japan, by the North British Company in conjunction with the English Electric Company, Limited. These locomotives, it will be remembered, were fully illustrated by means of two page plates and other engravings in our issue of January 25 last (page 97 *ante*.)

The Post Office Tube Railway.—The Postmaster General has placed the contract for the rolling stock and electrification of the Post Office Tube Railway with the English Electric Company, Limited, Kingsway, London.

THE BRITISH ASSOCIATION MEETING AT TORONTO.

(*Concluded from page* 449.)

SECTION B.—CHEMISTRY.

Liquid and Powdered Fuels.

The discussion on August 12 with Section C, Geology, was opened by Dr. G. S. Hume, of the Geological Survey, Ottawa, with a paper on "Liquid Fuels in Canada." The oil, at present mined in New Brunswick, Ontario and Alberta, he stated, was only 1·3 per cent. of the total oil consumption. Further borings in Alberta were very promising, and there were the 8,000 sq. miles of tar sands in Alberta, some of which gave 20 per cent. of bitumen carrying 69 per cent. of oil, and further the oil shales of New Brunswick, yielding as much as 36 imperial gallons of oil to the ton. But satisfactory processes for the extraction of the tar sands and shales had still to be worked out. On the other hand, the stripping of coke oven gas of benzole, started in 1915 by the Dominion Iron and Steel Company of Nova Scotia, had yielded a superior motor fuel, of low freezing point, which was an important consideration in Canada, of which 292,000 gallons had been produced in 1921. The coke oven industry of the country was also interested in this process.

Mr. H. D. Savage, of the Combustion Engineering Corporation, Limited, Toronto, followed with a paper on "The Advantages of Pulverising Fuels," which he illustrated by many slides of the 71 plants of his firm in various parts of America, several of which, he said, had been run for years. Locomotives fired with powdered fuel were running in Brazil and Japan. Any coal, from anthracite to lignites, could be powdered, and coal, oil or gas could be burnt in the same furnace. At the River Rouge plant of the Ford Motor Company four Ladd boilers, each of 26,000 sq. ft. heating surface were fed with blast furnace gas and powdered coal. There had at first been trouble with fused bricks. But if the powdered coal were introduced in a vertical jet, near the front wall, the velocity along the front need not exceed 15 ft. per second, so that the walls were not eroded, and the temperature near the wall would be 1,500 deg. F. and reach 2,700 deg. F. only in a small central zone. Air-cooled and water-cooled walls had removed all the difficulties.

In the next paper, on "Pulverised Coal for Metallurgical Plants," Professor G. A. Guess, of Toronto, mentioned that the International Nickel Company, of Copper Cliff, Ontario, had in 1914 first successfully used pulverised coal in reverberatory smelting, and powdered coal had subsequently been adopted at Anaconda. In both places a long-flame bituminous coal had been available; the want of such fuel accounted for the earlier failures of Sörensen in Utah and others, because parts of the furnace did not get hot enough. The ashes from powdered coal contained 25 per cent. of combustible matter, but the amount of ore smelted was raised by 50 per cent. Coal with 3 or 4 per cent. moisture was now sent direct to the pulverisers. As regards handling, the powdered coal might be delivered from a bin by a screw and be blown into the furnace by air; or it might be kept in continuous circulation at 70 ft. per second with 50 cub. ft. of air per pound of coal by means of fans, to be ready for use as soon as the valve was opened; the latter was preferable for large plants.

At the pyretic smelting plant of the Tennessee Copper Company powdered coal had been used instead of coke, and the gases from the blast furnace had been utilised for making sulphuric acid; the innovation had been abandoned only because the unconsumed coal had discoloured the acid. But at Copper Cliff they had not been able to replace more than 50 per cent. of the coke by powdered coal because the fuel was blown away. Similar experiments with powdered anthracite had been made at the blast furnaces of Cerro de Pasco, Peru; in the reverberatory smelter the powdered anthracite (with 8 per cent. of volatiles) had not answered, the furnace growing cold from the firing end. Thirty per cent. of volatiles was considered the minimum for metallurgical powdered coal. At the same plant, however, suspensions of powdered coke in oil had proved suitable, the oil serving as igniter. Powdered coal had many advantages, among them being the small stand-by loss in the case of boilers. In reverberatory smelting the efficiency was diminished by the necessity of melting the ashes. But powdered-coal boiler installations were becoming common; the Lead Company of the River Mines, Missouri, had a plant of 10,000-h.p. capacity and powdered the fuel at 50 cents per ton. The use of pulverised coal was receiving considerable attention in many parts of Canada.

Many questions were raised during the discussions of these various papers. Sir Henry Fowler referred to the cutting action of slags on English fire-bars, which were smaller than American. The absorption of moisture by powdered fuel was mentioned by Mr. E. A. Cunningham, of the Canadian Pacific Railway. Dr. J. W. Mellor considered the attack of the bricks by the ash the serious problem. Lieutenant Duncan thought that the difficulty was more with the quality of the bricks. Sir Max Muspratt mentioned that the United Alkali Company had been beaten twenty years ago by the cost of grinding and the corrosion due to the use of pulverised coal; both these difficulties were now overcome by water-cooled walls and other expedients. The difficulties of storing powdered fuel and the risk of explosion of electric boilers were also commented on, and Professor Bone spoke of the serious corrosion in such generators.

In his paper on "Brown Coals and Lignites" Professor W. A. Bone, F.R.S., touched upon developments of many problems which he had discussed in his Cantor lectures,* and he dealt further with the classification of sub-bituminous coals, brown coals and lignites, and their distribution within the Empire, for the purpose of urging a scientific brown-coal technology. Seams of brown coal, 253 ft. in thickness, such as found at Morwell in Australia, were probably unparalleled. The rich Canadian deposits were now being explored, but more co-ordination of the researches was required. Drying the brown coal would double its available energy, but the driers should be air-tight and contain no pockets nor sharp corners, to avoid the accumulation of dust; Professor Bone exhibited a drier of his design among his many slides. The yield of oil and tar from brown coal (8 per cent. in Australia) was not greater generally than from bituminous coal; Canadian brown coal gave only 3 per cent. The long paper, which was largely tabular, was discussed by Sir Robert Robertson and by Messrs. McCleat and R. E. Gilmore. The latter mentioned that a report on Canadian lignites had recently been issued; the lower black lignite of Western Canada was very friable, but might give satisfaction when briquetted and carbonised. In Ottawa they had adopted a geological classification which they sought to bring in harmony with chemistry. Professor Bone replied that they had at South Kensington compared all the lignites of the world; he used his own classification, and an international classification was not possible without exchange of samples and did not appear advisable for another five years.

Colloids.

The joint discussion, of Wednesday, August 13, with Section A, on "Colloids," was opened by Professor J. W. McBain, F.R.S., of Bristol, with a series of papers. In the first paper on "The Conception of the Electrical Double Layer in its Relation to Ionic Migration," he reviewed our knowledge of the double layer between liquids and walls of glass or membranes and colloidal particles, remarking that, while he had no intention of criticising Helmholtz's mathematics and calculations, he questioned his experimental basis. The accepted contact potentials had merely a fictitious value; Dr. McBain suggested that results should be recorded as observed, as movements in electric fields or as electromotive forces set up by bodily movement, and that most ions would be held to the wall, whilst a few were mobile. That view, which agreed with the behaviour of sols, gels and soap curds, was supported by Miss Laing, his collaborator, and partly by Professor Bancroft, but was adversely criticised by Professor Donnan and Dr. Rideal. There was general acceptance of Professor McBain's further papers on "The Rate of Saponification by Oils and Fats," on the "Use of Indicators" (in such studies he finds only three indicators suitable), and on the "State of Matter Exemplified by Soaps and Their Solutions." Soap, he demonstrated, formed an almost unique material for the study of states of aggregation. Any aqueous soap could be prepared in the form of hexagonal crystal lamellæ, of white crystalline curd fibres, transparent liquid crystals (anisotropic) and transparent isotropic solutions; the latter were dark with crossed nicols and were crystalloids or colloidal electrolytes, fluid or true jellies at different temperatures and concentrations.

* See Engineering, vol. civ, pages, 682, 715, 749; December, 1922.

Concluding Remarks.

The exertions of the local committee and the Association officials for the Toronto meeting were crowned with signal success. It was a great and enjoyable gathering, and everybody heartily joined in the thanks to which Sir David Bruce and Sir Ernest Rutherford gave expression at the concluding meeting. Sir Ernest spoke almost with envy of the splendid equipment of the Toronto Laboratories, and Principal E. Barker, of King's College, London, mournfully referred to the vision of our own country having public elementary schools built and equipped as in Toronto. Professor C. Venkata Raman brought greetings from India, and Sir Henry Fowler looked forward to great industrial developments on the St. Lawrence. Professor Millikan, of California, thanked Canada for the inspiration from across the border; that obligation was certainly mutual. The attendance figure, 2,825, has only been surpassed eight times, the last time last year at Liverpool; there is no previous record of two great consecutive meetings. We hope to deal later with the discourse delivered by Professor Eddington during the meeting, which did not really close on August 13. We will deal later with the excursion to Edmonton, Vancouver and Victoria, which were really part of the meeting, as at previous meetings in Canada, South Africa and Australia. Thanks to the large attendance, the research grants of 1,086*l.* once more reached the pre-war average.

Next year the Association will meet in September at Southampton under the presidency of Professor Horace Lamb. The exact date has not been fixed yet.

ELECTRICALLY EQUIPPED KITCHENS ON TRAINS.

The first restaurant car saloon to be run on any railway in Great Britain was introduced into the service between King's Cross and the North in September, 1879. In this pioneer contribution to the comfort of the travelling public, coal fires and oil lamps were used for cooking purposes. As a contrast to this and one indicating the measure of improvement in facilities to meet the requirements of an exacting public, the new triple restaurant car sets now put in use on the London and North Eastern Railway may be referred to. This equipment consists of dining accommodation in separate carriages for first-class and third-class passengers, with a kitchen car interposed between them. The arrangement is made on the articulated principle, four bogies being used for the support of the three cars, with the intermediate bogies under the ends at the junctions to the kitchen car.

The advantages of electric cooking apply to a greater extent on a train than in a house or restaurant. A cool and pure atmosphere may be maintained in the kitchen car and this advantage results in better attention on the part of the staff. It is due to the enterprise of Mr. H. N. Gresley, the Chief Mechanical Engineer of the London and North Eastern Railway, that this new development in electric cooking has been made possible. The whole of the apparatus was supplied by Messrs. J. Stone and Company, Limited, of Deptford, London, who also provided the electric lighting equipment for the train. The Jackson Electric Stove Company made the cooking range, ovens and boilers to meet the special requirements of the installation. In Figs. 1 and 2, views are given of the kitchen car, from which the compact way in which the apparatus is assembled for use in working will be appreciated.

At one end of the kitchen the main cooking range is fitted, and on the left there is a roasting oven with a steaming oven, grill and hot water tank superimposed. Beside these there is a boiling range with six hot plates for frying or boiling, and one boiling pan

ELECTRICALLY-EQUIPPED TRAIN KITCHEN; L.N.E.R.

Fig. 1.

Fig. 2.

of seven gallons capacity, which is used for cooking vegetables. Between the serving hatches on one side of the kitchen a hot cupboard is fitted, which has sufficient capacity to heat the whole of the plates required for the service, and its top forms a convenient table. Two urns each of two gallons capacity and two kettles of six pints size are available for boiling water for teas, and to supplement what can be obtained from the boiler on top of the oven range. Hot water for washing purposes constitutes a continuous demand on the available electric energy, and two 45-gallon tanks for warm water are, therefore, fitted in the roof of the corridor alongside the kitchen. The heating elements for these are clamped to the underside of the tanks. As this supply is used for the feeding of the boiler, kettles and urns, it is possible to obtain boiling water very quickly. To minimise the capacity and weight of the electric plant, connecting plugs and sockets are provided on the train, so that when it is in terminal stations electrical energy for preliminary operations may be drawn from the station supply system.

A main throw-over switch enables the load to be switched over from the preliminary alternating-current supply at the railway station to the direct-current supply from the dynamo and batteries on the train. Subsidiary boards are provided for each group of the cooking appliances in the equipment, carrying separate switches for the control of each element. Pilot lamps above the switches, with red glasses bearing the name of the apparatus the switch controls, indicate when the operations are in progress. The electrical energy while the train is under way is provided by two dynamos of their "Lilliput" type made by Messrs. J. Stone and Co., Limited. These are installed on the underframe of the kitchen car. They are of 7·2-kilowatts capacity, have self-contained automatic pole changing and are belt-driven from the axles of the carriage. During intermediate stops, the cooking operations are continued by the use of current from a battery of accumulators. Automatic switchgear is provided for the control of the machines in order that they be connected up to the cooking equipment when a predetermined speed is attained, and disconnected when a lower speed is reached. A battery overcharge prevention switch automatically diverts a part of the current from the batteries when they reach the fully-charged condition. This current is passed to the supplementary heaters of the warm-water tanks in the corridor. The automatic cut-in switches and potential overcharge switches are of special design, constructed on the principle of the standard apparatus of Messrs. J. Stone and Co., Limited, but, to suit the higher voltages of this application, they are of the double-pole type, with carbon breaks on each pole. The battery comprises 90 cells, of which the dimensions are 4¾ in. by 6½ in. by 13¾ in., and they are each provided with 15 plates each. They are housed in ebonite boxes with sealed lids and have screwed vent plugs for testing the acid and for refilling. All the wiring is carried out in enamelled screwed conduits which are earthed, as also are the casings or frames of the cooking appliances. For safety, the plug connections for electrical supply at terminal stations are interlocked with a valve on the train pipe, so that a vacuum cannot be created in the train pipe if the plug is connected.

The prevailing note in the decoration of the restaurant cars is extreme simplicity, the walls of the first-class cars are lined with mahogany panels and the seats are of the arm-chair type, with green Morocco leather upholstery. Green indiarubber is used, over felt, for the flooring. In the third-class carriages, the upholstery is in crimson and black plush. A trial run between King's Cross and York was given to the new trains on Monday, September 29, when the non-stop journey was accomplished, with a train of 370 tons weight drawn by a Pacific type locomotive, in 3 hours 38 minutes, the schedule time.

THE REFRACTORY SECTION OF THE CERAMIC SOCIETY.

(*Concluded from page* 461.)

The Influence of Exposure on Fireclays.

Experiments to determine the effect of weathering on fireclays were described in a paper entitled "The Influence of Exposure on the Chemical and Physical Properties of Certan Fireclays," which was contributed by Messrs. W. Hugill and W. J. Rees, B.Sc. The purpose of the experiments made was to investigate the nature of the changes occurring in the case of fireclays exposed for a fixed period, during which the meteorological conditions were recorded.

Samples of fireclay were taken from three localities: 1. A light grey, somewhat sandy, micaceous clay, which forms the scab earth of the Lower Busty Seam, Co. Durham; 2. A dark coloured, compact, fine-grained clay from the Pot Clay Bed of the Sheffield district; 3. A light grey, very sandy and micaceous variety from the same stratum as No. 2, but from a different locality. Some of each clay was made into bricks, another portion being spread evenly over the bottom of a wooden box and left exposed in the open air for 12 months. Bricks were afterwards made of the clays which had been exposed, and various tests were carried out. Details were given as to meteorological conditions, analyses, &c. Clays 1, 2 and 3 contained respectively about 61, 51 and 63 per cent. of silica, with about 26, 30 and 20 per cent. of alumina, the percentages being altered somewhat after exposure.

The authors concluded from the results that exposure to the weather removed impurities in the clay to a variable extent, depending on their chemical and physical characteristics. It improved the working properties of the silicious clays (Nos. 1 and 3), but in the case of the more aluminous clay (No. 2), whilst some impurities were removed (notably some of the iron sulphide), the general properties, and in particular the workability, were not materially improved by exposure. Mr. Rees added verbally that bacteria seem to play an important part in the decomposition of the sulphides, and that such decomposition might possibly be speeded up by inoculation with suitable bacteria.

Alumina—Silica Minerals in Firebricks.

A paper by Mr. W. J. Rees, B.Sc., on the above subject recounted experiments on five different kinds of firebricks.

Finely powdered samples were exposed under similar conditions as to temperature to the action of pure hydrofluoric acid for 12 hours, the amount of the insoluble residue and its composition being ascertained in each case. Similar tests were applied after re-burning at cone 18 and cone 26 respectively. In all cases the amount of insoluble matter increased considerably with increase of firing temperature, the percentage in the case of the first brick being 14·4, increased to 18·9 and 34·4 after re-burning at cone 18 and cone 26 respectively. The composition of the insoluble residue ranged mostly between 72·9 and 70·9 per cent. of alumina, 27·0 to 25·9 silica, and 0·2 to 2·1 of ferric oxide, which agreed fairly well with that of Bowen and Grieg's mineral mullite $3\,Al_2\,O_3 \cdot 2\,SiO_2$ (= $Al_2\,O_3$ 71·8, SiO_2 28·2). In the case of one brick the residue gave on analysis just under 70 per cent. alumina and just over 29 per cent. silica, which again approximated to the composition of mullite. Another brick had a composition approximating rather to $4\,Al_2O_3 \cdot 3\,SiO_2$, but after re-burning at higher temperatures the composition of the residue became similar to the others.

The Storage of Silica Refractories.

In a paper, entitled "A Note on the Storage of Silica Refractories," the author, Mr. W. J. Rees, B.Sc., called attention to the fact that the neglect to exercise care in storage of silica bricks and blocks was liable to cause considerable changes in properties, particularly in the mechanical strength and spalling tendency. For instance, the author had noticed that a batch of silica bricks which had been stored in the open for six months spalled badly in use, whilst normal freshly-delivered bricks of the same make, and having the same texture, &c., were satisfactory. The good bricks had a cold crushing strength of 3,000 lb. per square inch, whilst that of the stored bricks was only 2,200 lb. per square inch.

Two batches of commercial silica bricks, one coarse and the other of moderately-fine texture, and possessing very similar composition and properties, were used for testing, 12 bricks of each batch being placed in the open, unprotected from the weather, for four months. Some were also placed under similar temperature conditions, but protected from the weather, and others again were placed in a warmed store-room. Besides tests for mechanical strength the test-pieces were subjected to special treatment by boiling in water, soaking in water, and spraying with water respectively. The results furnished definite indications that the loss in strength of silica bricks exposed to weather, was, in part, due to a slight degradation of the bond by

hydration and solution in water, as well as to the physical effect of frequent wetting and drying.

In these tests, there was little or no distinction in the behaviour of the coarse and fine-textured briquettes, but in both cases the briquettes burned at higher temperatures were more resistant to the water attack. This test was an approximation to the storing of bricks in the open without protection, and the results further emphasize the need for suitable protection of silica bricks during storage.

Determination of Specific Gravity.

The next paper was entitled "A Rapid Method for the Determination of True (or Powder) Specific Gravity," and was contributed jointly by Messrs. W. Hugill and W. J. Rees. The apparatus used was a 250-c.c. glass flask, with a graduated neck, the lower part of the neck being enlarged into a globular bulb. At the bottom of the neck, below the bulb was the 250-c.c. mark. The neck was graduated in specific gravities from 2·00 to 2·70, so that the specific gravity might be read off directly without calculation. For making a determination, which took from 15 to 20 minutes (most of the time being used in crushing the brick), not less than one quarter of a brick was crushed so that it would all pass through a 30-mesh sieve. The flask was then filled with xylene up to the 250-c.c. mark. Exactly 100 gms. of the crushed brick were then weighed out in a counterpoised scoop and sprinkled into the flask. The flask was gently agitated to free any air-bubbles which might have been carried down. After standing for two minutes, the powder density was read directly from the level of the liquid in the graduated neck of the flask. The conside ations which led to the adoption of xylene as the liquid to be used with the flask, and to the maximum grain-size indicated by passing through a 30-mesh sieve, were fully explained in the paper. Both xylene and toluene had much lower viscosity than alcohol or water, and they also had low surface tension. The higher boiling point of xylene was the deciding factor. Results obtained indicated that accuracy to plus 1 or minus 1 in the second place of decimals could be expected from the method, provided that the crushed brick was dried.

Properties of Lime-bonded Silica Bricks.

The last paper of all, entitled "The True Specific Gravity and After-Expansion of Lime-bonded Silica Bricks," was also contributed by Mr. W. J. Rees. The data for 40 bricks which had been examined were given in a graph and table of analyses, with certain physical properties. The bricks were from North and South Wales, the Sheffield district, North of England, Scotland, and France. The following points were to be noted:—(*a*) That for bricks of lime content between 1 per cent. and 3 per cent., there was a sufficiently close relation for practical purposes between the true specific gravity (or powder density) and the degree or extent of quartz conversion; (*b*) That for bricks of fine and medium texture there was a close relation between the true specific gravity and the after-expansion as determined by the standard after-expansion test. For works purposes, a rapid determination of the powder density of such bricks gave a definite indication of the permanent volume change which was likely to occur during their use; (*c*) That for the raw materials which were in use in this country for the making of lime-bonded silica bricks, the grading of the raw material had in general a greater influence on the rate of quartz conversion than variations in the source or type of the raw material itself; (*d*) That for coarse-textured bricks containing large fragments of raw material (i.e., ¼-in. and above in diameter), there was not a close relationship between the true specific gravity and the after-expansion. This was probably due to the slower rate of inversion of the coarse fragments and their less intimate association with the lime in the matrix of the brick. It suggested the possibility that for coarse-textured bricks, the time of heating in the standard after-expansion test was insufficient. In the case of two of the bricks with coarse texture, doubling the period of heating at 1,410 deg. C., increased the after-expansion and brought it into relationship with the true specific gravity of the brick.

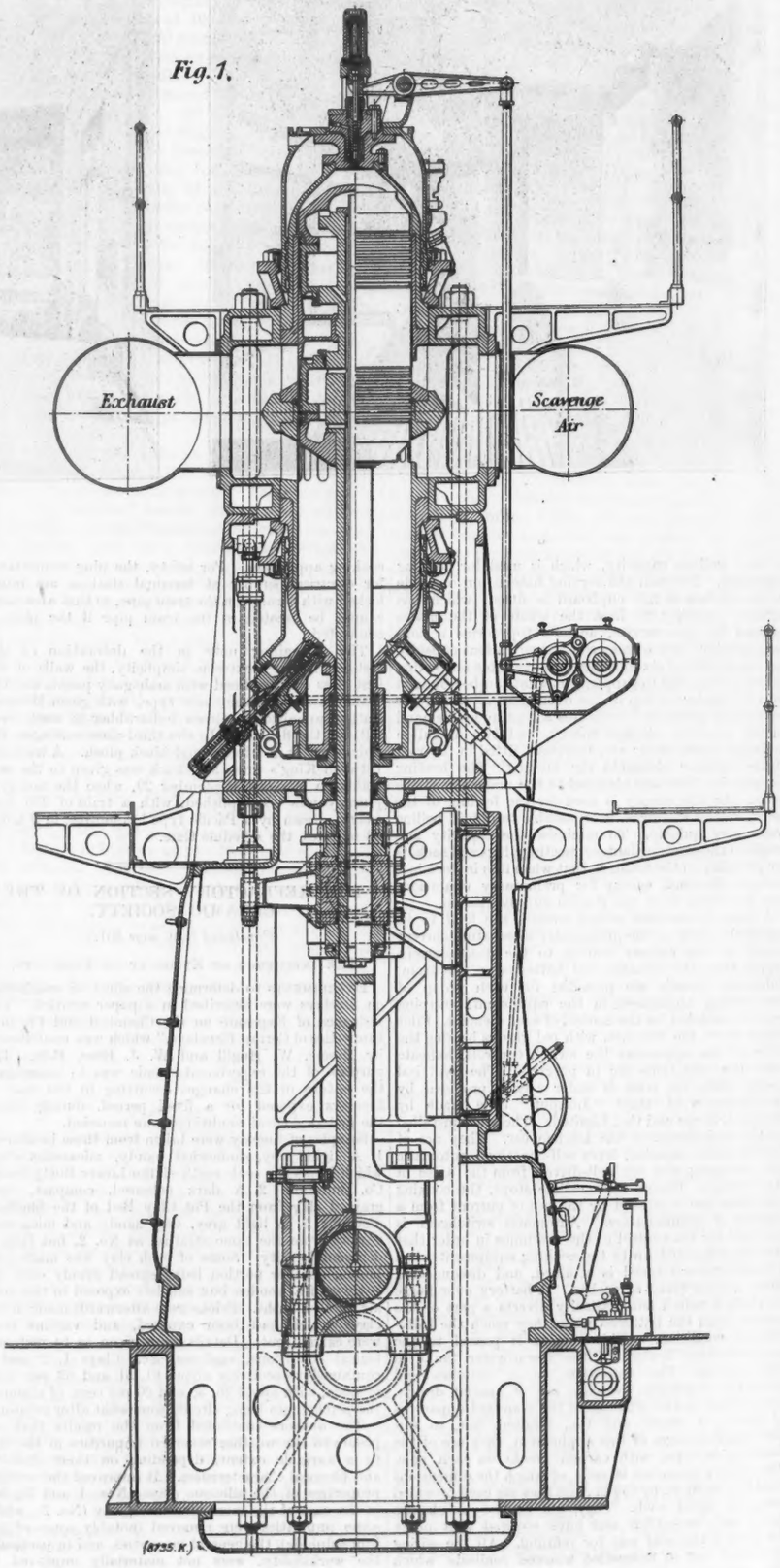
THE WORTHINGTON 2-CYCLE DOUBLE-ACTING DIESEL ENGINE.

In spite of the position which the single-acting four-stroke type of oil engine has attained, there have never been wanting engineers who believed that it was only a matter of time before questions of the more economical use of material would compel greater attention to designs involving more than one working stroke per two revolutions. The two-cycle, single-acting engine has, indeed, already proved itself a very severe competitor of the older type, especially in the larger sizes, and the next step lay in the direction

2-CYCLE DOUBLE-ACTING DIESEL ENGINE.

THE WORTHINGTON PUMP AND MACHINERY CORPORATION, BUFFALO, N.Y.

Fig. 1.



2-CYCLE DOUBLE-ACTING DIESEL ENGINE.

THE WORTHINGTON PUMP AND MACHINERY CORPORATION, BUFFALO, N.Y.

FIG. 2. PISTON COMPLETE WITH ROD.

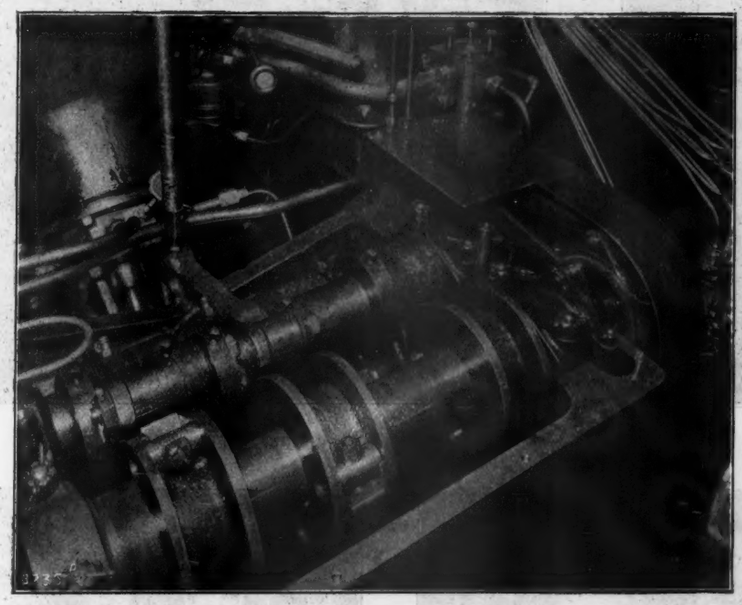


FIG. 3. CAMSHAFT IN POSITION.

FIG. 4. CAMSHAFT DRIVE AND REVERSING CYLINDER.

of evolving a practical design of engine having two working strokes per revolution. Such a design would place the heavy oil engine on nearly the same basis as the steam engine so far as evenness of turning effort and weight for power developed are concerned, and, regarding it as the logical development of heavy oil-engine practice, the Worthington Pump and Machinery Corporation have recently constructed the two-cycle double-acting engine, which we illustrate in Figs. 1 to 10, on pages 482 to 485, in their works at Buffalo, N.Y.

In view of the somewhat experimental nature of the engine, the first unit was constructed with a single cylinder only, it being, of course, a simple matter to arrange for the combination of as many cylinders as desired for the development of larger powers. The engine illustrated, however, is by no means a small one, the cylinder being 27 in. diameter by 40-in. stroke and developing from 600 to 800 brake horse-power at 90 to 120 revolutions per minute. These ratings correspond to a mean effective pressure of about 61 lb. per square inch referred to the brake horse-power. At the lower speed about 316 brake horse-power is developed in the upper end and 284 brake horse-power at the lower end of the cylinder, the difference, of course, being accounted for by the presence of the rod in the latter. In the case of a multi-cylinder engine, each working cylinder, with its running gear, frame, &c., will form a complete unit, each frame having on either side a large flange for bolting to an adjacent cylinder unit, scavenging air-compressor unit or end cover, as desired. A cast-iron bedplate common to all cylinders will make a continuous crank-case for the whole engine, the design providing ample room for lifting main bearing caps, &c.

Referring to the particular engine illustrated, the details of which may be taken as similar to those which would be used for a multi-cylinder engine, the frame supporting the working cylinder is of cast-iron of box section with a large door in front and a smaller one on the rear side. It supports a cross-head guide, which is a separate casting with astern bars. The working cylinder is supported by a cast-iron cylinder housing bolted to the top of the main frame. To this housing the cast-iron cylinder base is attached by means of four tie bolts which extend from the top of the base to the bottom of the bedplate, so that the framing is relieved from the tensional stresses due to the working of the engine. The cylinder base serves to introduce the scavenging air to the cylinders and to lead the exhaust gases away, a scavenging-air manifold and an exhaust manifold of steel plates being bolted on opposite sides of the base. The top and bottom of the cylinder base are held together by the side walls and by 16 hollow water-cooled bridges passing across the scavenging and exhaust ports. These ports register with corresponding ones in the top and bottom cylinder liners.

The cylinders consist each of a forged shell of heat-treated chrome-vanadium steel, into which is pressed a cast-iron liner containing the inlet and exhaust ports. Each cylinder is clamped to a projecting internal flange cast in the cylinder base, by means of a clamping ring resting on a shoulder on the steel shell and held down by 16 heavy studs. A cast-iron water-jacket is bolted to the free end, of each cylinder and its other end slides in a stuffing-box in the clamping ring so that the cylinder can expand and contract independently of the jacket. The cooling water is led to the water-cooled bridges of the cylinder base and passes through them to the water-jackets by means of holes in the ends of the cylinders. At the top of the upper cylinder and at the bottom of the lower cylinder are valves by means of which the cooling water can be regulated. It will be clear that each end of the double-acting cylinder is virtually an independent single-acting cylinder, having its own air and exhaust ports, its own cooling-water system, and its own attachment to the engine framing. The combustion space which is formed by the domed end of the steel cylinder is of extremely simple shape, and this fact, together with its comparative thinness and the nature of the material employed, eliminates the likelihood of trouble from cracks.

The lubrication of the cylinder walls is provided for with special care. Holes are drilled through every alternate one of the water-cooled bridge-bars in the cylinder base, and oil is thus introduced to a part of the liner which is always covered by the piston. Efficient cooling of the lubricated surface over which the rings slide is very necessary, and is assured by compelling a high velocity of the cooling water by means of guiding walls inside the jacket at this point. In the top of the upper cylinder is placed one fuel valve, and in the bottom of the lower cylinder are two fuel valves, one on each side of the rod. Each of these valves has an independent valve motion actuated by its own cam on a camshaft common to all the valves. Air injection is used.

The piston is constructed like two single acting pistons mounted on the same piston rod. The piston heads are forged of heat-treated chrome vanadium steel, bolted to a flange on the rod. To each piston head is bolted a cast-iron sleeve carrying the piston rings. This sleeve is guided at its free end by a flange on the piston rod, which keeps it in line and forms an end to the watercooled space of the piston, water-tightness being secured by a rubber packed stuffing-box. The centre-piece of the piston is made in halves, and is secured by two heavy bolts. It is prevented from sliding on the rod, but the top and bottom pistons can slide upon it when they expand or contract under varying temperatures. The piston rod is hollow and contains a central tube for the circulation of the cooling water. The rod is fastened to the crosshead by nuts above and below the latter. Telescopic pipes, one for the incoming and one for the outgoing cooling water of the piston, are arranged outside the engine casing. The

2-CYCLE DOUBLE-ACTING DIESEL ENGINE.

THE WORTHINGTON PUMP AND MACHINERY CORPORATION, BUFFALO, N.Y.

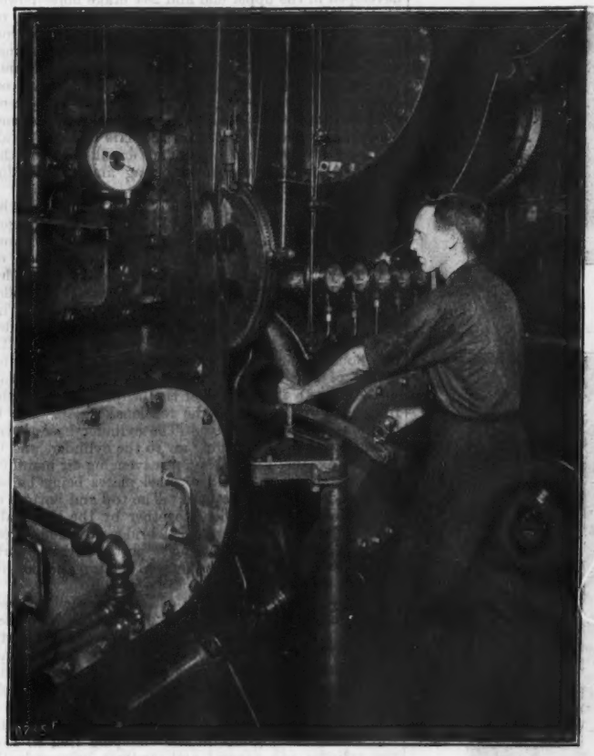


Fig. 5. Interlocking Control Gear.

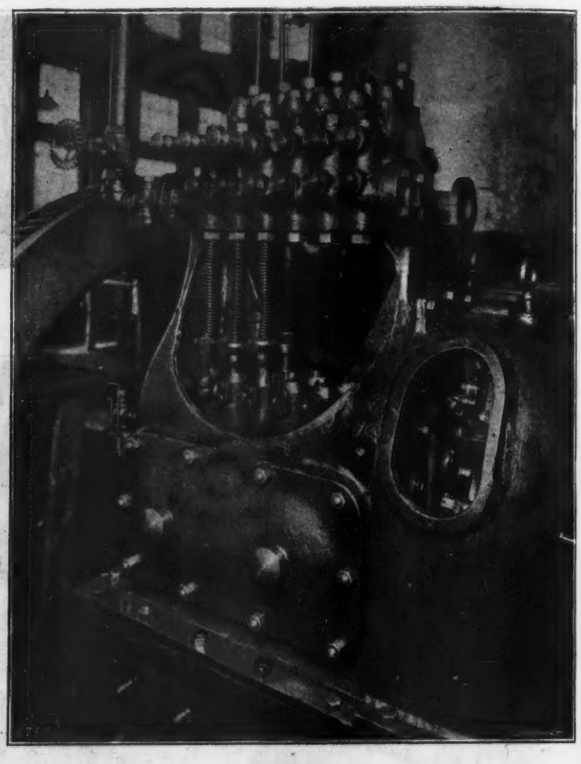


Fig. 6. Fuel Pumps.

crosshead is of forged steel, with a cast-steel shoe faced with whitemetal, bolted to the back side. The connecting rod is forked at the crosshead end, the general design being shown in Fig. 8.

The scavenging air compressor is combined with the compressor for the injection air. The former consists of two cylinders in tandem with pistons mounted on a common rod. The cross-head on the rod serves as the piston of the first stage of a four-stage compressor for the injection air. The other three stages are built in one cylinder fixed at the rear of the engine and operated by a beam from the connecting rod, which also drives the scavenging air compressor. For starting the engine, air at from 200 to 350 lb. per square inch is used. All the fuel injection valves are driven from a single camshaft. The cams are symmetrical, so that they will operate the fuel valves in the same way, whether the engine is running ahead or astern. To set the fuel valves for going astern, the camshaft has to be turned through 34 degrees, relatively to the crankshaft. To reverse the air-starting valves, the layshaft is slid longitudinally so as to present a second set of cams to the relay valves.

These two operations are accomplished as follows:—The camshaft is driven by means of a vertical shaft which has a set of bevel gears at each end. The horizontal lower bevel is mounted on a sleeve supported on two bearings and the horizontal layshaft passes through this sleeve and drives it by means of a feather. The layshaft is driven from the crankshaft by cast-steel helical spur gear. If now the layshaft is moved axially, the effect of the helical gear is to turn it, and, therefore, the camshaft, through the required angle to bring about the reversal of the fuel injection valves. The longitudinal motion of the layshaft also reverses the air relay valves by bringing them under the action of another set of cams. A bronze piston on the layshaft operated by the pressure of the lubricating oil causes the axial motion of the layshaft required to reverse the engine. The oil cylinder containing this piston, and part of the helical gear is shown in Fig. 4.

The builders of the engine, the Worthington Pump and Machinery Corporation, are represented in this country by Messrs. Worthington-Simpson, Limited, of Queen's House, Kingsway, London, to whom we are indebted for illustrations and particulars. The design is a bold one in many respects, but the greatest simplicity which the principle admits of has been maintained throughout, and the long experience of the Worthington Corporation as Diesel engine builders, gives an added interest to their latest development.

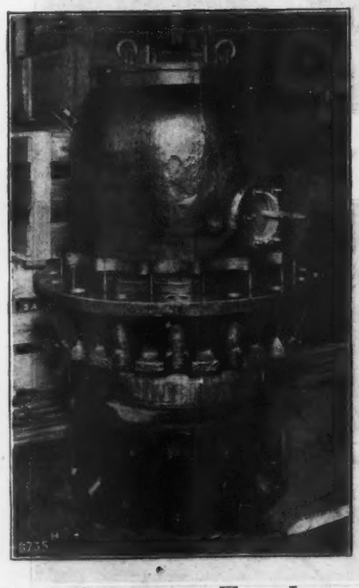


Fig. 7. Cylinder with Water Jacket.

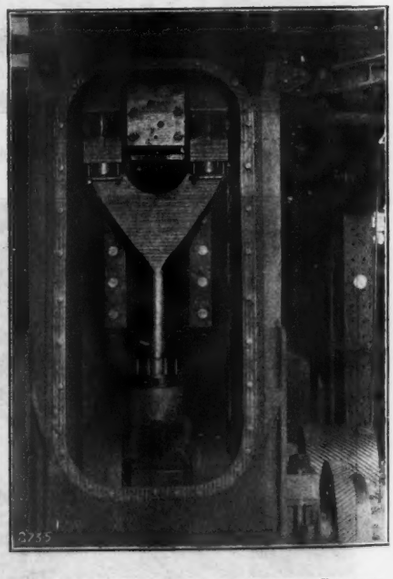


Fig. 8. Cross Head and Piston Cooling Pipes.

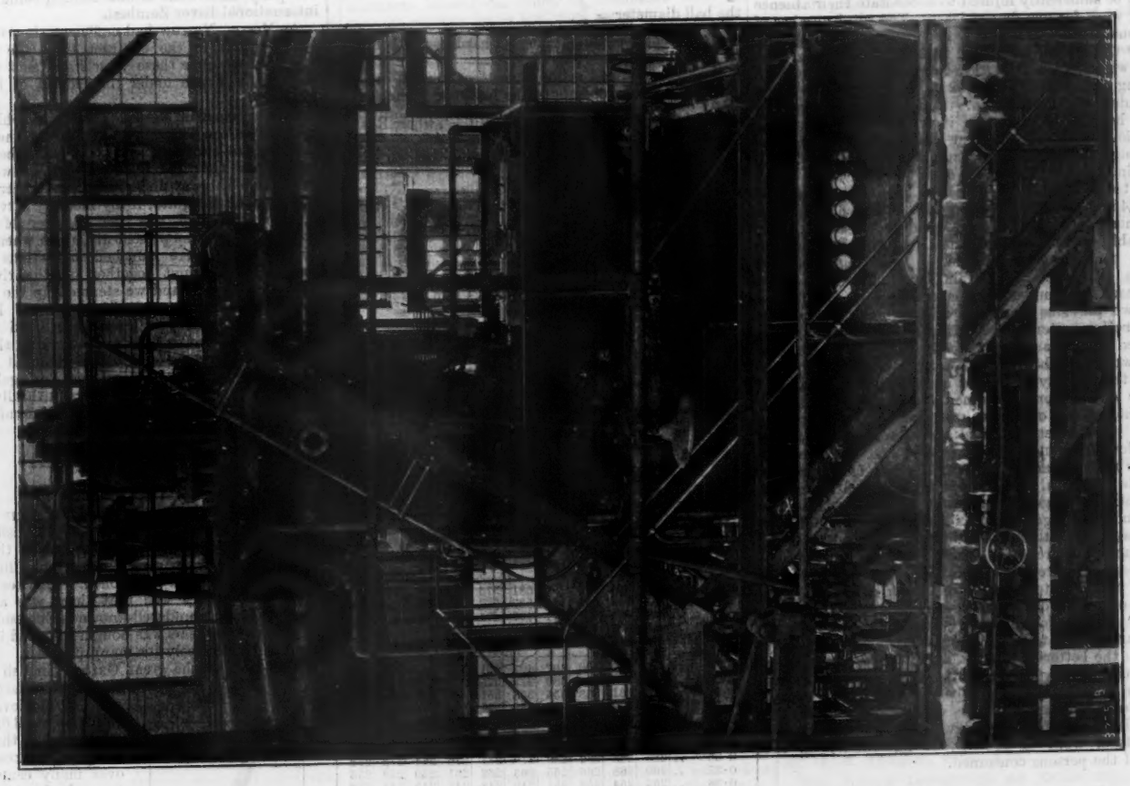
ACCIDENTS ON THE RAILWAYS OF GREAT BRITAIN DURING 1923.

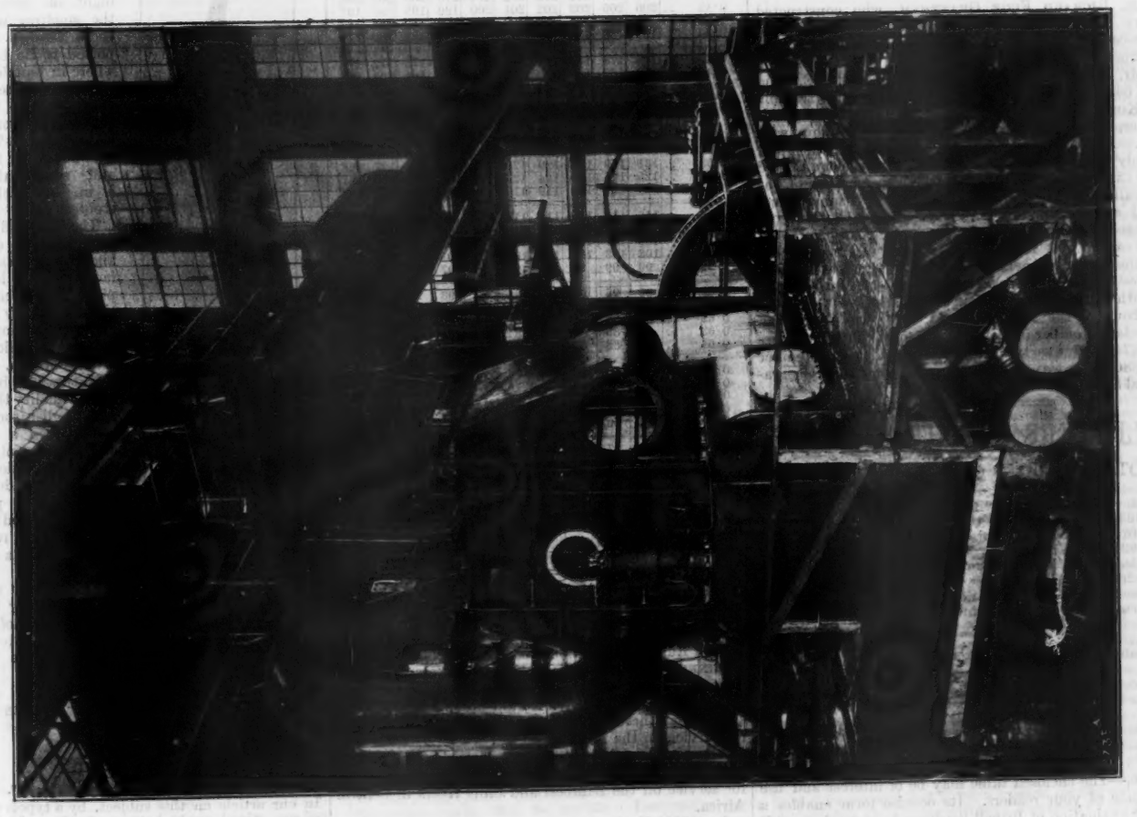
In his annual report presented to the Ministry of Transport (Report to the Ministry of Transport upon the Accidents that occurred on the Railways of Great Britain during 1923, Cmd. 2256), Colonel J. W. Pringle gives a valuable analysis of the figures at his disposal relating to railway casualties. Accidents on the 51,818 miles of track in the country are grouped in the report under three main heads, namely, those sustained by trains, those by moving railway vehicles, and non-movement misadventures on railway premises. These groups are further sub-divided according as they relate to passengers, servants, and other persons. It must be borne in mind, however, that all accidents

2-CYCLE DOUBLE-ACTING DIESEL ENGINE.

THE WORTHINGTON PUMP AND MACHINERY CORPORATION, BUFFALO, N.Y.

(*For Description, see Page 482.*)





FIGS. 9 AND 10. VIEWS OF ENGINE ON TEST BED.

to passengers which occur during the working of railways require to be reported, however slight, while servants must be sufficiently injured to necessitate their absence from work for one day at least. The total number of persons killed in all classes in 1923 amounted to 743, while the injured numbered 23,240. The figures compare with 1,008 and 26,628 respectively for the average during the decade 1912–1921.

Under the first group, train accidents, inquiries were held in 26 cases and it transpired that in four collisions attended with the loss of the lives of three passengers and seven servants, failure of single-line working was not the cause of any one of these cases. The total number of collisions for the 12 months was 246, derailments totalling 418. These figures show an increase over the corresponding ones for 1922, probably more apparent than real, in view of the more comprehensive system of reporting accidents which is now in use. Train coupling failures have increased in number in comparison with the figures for two previous years; possibly this is due partly to a better system of reporting and partly to the increased loads carried by goods trains. The returns as a whole for the year again, as in previous Reports, show the liability to danger in the conduct of railway traffic either from signalmen forgetting the position of light engines, or engines with brake vans on running lines. Of the persons killed and injured while passing over level crossings, 15 were killed and 11 injured at public road crossings, 11 were killed and 3 injured at private crossings, and 11 were killed and 3 injured at footpath crossings. As a result of inquiries into the first and second group of accidents only 181 or 6·79 per cent. were found to be due to directly preventable causes. The accidents reported under the second group—accidents of movement—for 1923, both fatal and non-fatal, continue to show a reduction compared with those occurring during the years prior to 1921. The higher figures for non-fatal accidents for 1923 as compared with the two previous years is probably due to the better facilities afforded for reporting cases since the railway amalgamation, and to some extent to the increase in the number of passenger journeys and train mileage. In the case of passengers the 66 killed and 2,262 injured were largely due to misadventure, want of caution, or misconduct on the part of the persons concerned.

THE LATE MR. R. F. GRANTHAM.

Mr. Richard Fuge Grantham, who constructed many British waterworks, sewerage works and coast defences, died at his residence, 19, Daleham-gardens, Hampstead, on Friday, September 26. He was the son of Mr. Richard Boxhall Grantham, M.Inst.C.E., and was born in 1845. After receiving a scientific training at King's College, London, he was articled to his father, and in 1878 was taken into partnership with him. Amongst his works may be mentioned the water supply of Littlehampton, sewerage works at Enfield and Cirencester, the repair and reconstruction of the seawalls at Canvey Island in the River Thames, river walls at Fulham and on the River Swale. He constructed the seawalls at Westgate on the coast of Kent, and carried out many drainage and sewerage works for the Commissioners of Woods and Forests and the Ecclesiastical Commissioners. With his father, Mr. Grantham completed the reclamation of Brading Harbour in the Isle of Wight. He was elected an Associate Member of the Institution of Civil Engineers in 1874, and was transferred to the class of Member in 1886. He was also a Fellow of the Royal Geographical Society.

LETTERS TO THE EDITOR.

"ROTATING DISCS OF CONICAL PROFILE."

To the Editor of Engineering.

Sir,—In the leading article, in your issue of September 19, 1924, you state, that the stresses produced by rotation in a disc of conical profile had been first dealt with in 1923, in the article, "Rotating Discs of Conical Profile," published in your periodical on January 5 and 26. I beg to inform you, that this subject had previously been mathematically solved in § 11 of my dissertation, which was printed in 1919.

Yours truly,
E. Honegger.

Susenbergstrasse 85
Zürich 7, September 29, 1924.

A RAPID EVALUATION OF BRINELL HARDNESS.

To the Editor of Engineering.

Sir,—The enclosed table may be of interest and use to some of your readers. Its concise form enables a rapid evaluation of Brinell hardness to be made, and it is applicable to any ball diameter or load ratio, these being selected to suit the material under test.

The value of the hardness figure is obtained thus:—

(*a*) The diameter of the ball impression is divided by the ball diameter $= \frac{d}{D}$.

(*b*) The corresponding value for hardness is then read off in columns 0–9.

In the case of load ratios other than 30 (that used by Brinell for measurements of the hardness of steel), the value obtained must be multiplied by $\frac{R}{30}$, where R is the load ratio used.

An example will make this clear:—

Ball diameter, $D = 5$ mm.
Load, $W = 250$ kilos.
Load ratio, $\frac{W}{D^2} = 10$.
Impression diameter, $d = 2{\cdot}12$ mm.
$\frac{d}{D} = 0{\cdot}424$ mm.
Hardness $= 201 \times \frac{10}{30} = 67$.

I am, yours faithfully,
B. C. Gale, A.C.G.I., A.I.C.
Chemistry and Metallurgy Branch, Artillery College, Woolwich, S.E. September 27, 1924.

Brinell Hardness Table.

$\frac{W}{D^2} = 30$.

$\frac{d}{D}$ (mm.)	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.
0·24 ..	654	648	643	637	631	626	620	616	611	605
0·25 ..	600	595	590	586	581	576	571	567	562	558
0·26 ..	553	549	545	541	537	532	528	524	520	516
0·27 ..	512	509	505	501	497	494	491	487	483	479
0·28 ..	476	473	470	466	463	460	457	453	450	447
0·29 ..	444	441	438	435	432	429	426	423	420	417
0·30 ..	415	412	409	407	404	401	398	395	393	390
0·31 ..	388	385	383	380	377	375	373	371	368	365
0·32 ..	363	361	358	356	353	351	349	347	345	343
0·33 ..	341	339	337	335	332	331	329	326	324	322
0·34 ..	320	318	316	314	313	311	309	307	305	304
0·35 ..	302	300	298	296	295	293	292	290	288	287
0·36 ..	285	283	282	280	279	277	275	274	272	271
0·37 ..	269	268	266	265	263	262	261	259	258	256
0·38 ..	255	254	252	251	249	248	247	245	244	242
0·39 ..	241	240	239	237	236	235	234	232	231	230
0·40 ..	229	227	226	225	224	223	221	220	219	218
0·41 ..	217	215	214	213	212	211	210	209	208	206
0·42 ..	206	205	203	202	201	200	199	198	197	197
0·43 ..	196	195	194	193	192	191	190	189	188	187
0·44 ..	187	186	185	184	183	182	181	181	180	179
0·45 ..	178	178	177	176	175	174	173	173	172	171
0·46 ..	170	169	169	168	167	166	165	164	164	163
0·47 ..	163	162	161	160	159	159	158	158	157	156
0·48 ..	155	155	154	154	153	152	151	151	150	149
0·49 ..	149	148	147	146	146	145	145	144	143	143
0·50 ..	142	142	141	140	140	139	139	138	137	137
0·51 ..	136	136	135	135	134	134	133	133	132	131
0·52 ..	131	130	130	129	129	128	128	127	127	126
0·53 ..	125	125	125	124	124	123	123	122	122	121
0·54 ..	121	121	120	119	119	118	118	118	117	116
0·55 ..	116	116	115	115	114	114	113	113	112	112
0·56 ..	112	111	111	110	110	109	109	108	108	107
0·57 ..	107	107	106	106	106	105	105	104	104	104
0·58 ..	103	103	103	102	102	101	101	100	100	100
0·59 ..	99	99	98	98	98	97	97	96	96	95
0·60 ..	95	95	95	94	94	94	93	93	92	92
0·61 ..	92	91	91	91	90	90	90	89	89	89
0·62 ..	88	88	88	87	87	87	86	86	86	85
0·63 ..	85	85	85	84	84	84	83	83	83	82
0·64 ..	82	82	82	81	81	81	80	80	80	79
0·65 ..	79	79	78	78	78	77	77	77	77	76
0·66 ..	76	76	76	75	75	75	75	74	74	74
0·67 ..	74	74	73	73	73	73	72	72	72	72
0·68 ..	71	71	71	71	70	70	70	70	70	69
0·69 ..	69	69	69	68	68	68	68	67	67	67
0·70 ..	67	67	66	66	66	66	65	65	65	65
0·71 ..	65	64	64	64	64	64	63	63	63	63
0·72 ..	63	62	62	62	62	62	61	61	61	61
0·73 ..	61	60	60	60	60	59	59	59	59	59
0·74 ..	58	58	58	58	57	57	57	57	56	56
0·75 ..	56	—	—	—	—	—	—	—	—	—

LIGHT DRAUGHT RIVER VESSELS.

To the Editor of "Engineering."

Sir,—Adverting to your article on "The Navy at the British Empire Exhibition," on page 459 of this week's Engineering, when commenting on Messrs. Yarrow's special light-draught river vessels, *re* the earlier type built vessels, H.M.S.S.W. Herald and Mosquito, it is stated that these vessels were built for the Admiralty for service on the Niger.

Allow me to point out that the Herald and Mosquito were originally built for the Portuguese Government for service on the Zambesi and Shiri rivers in Central Africa.

In 1890 England very nearly declared war on Portugal, due to Maj. Serfa Pinto's action at Chiromo in holding up the James Stevenson, a light-draught stern-wheel steamer belonging to The African Lakes Company, also *re* the Chinde Mouth being part of the international River Zambesi.

As Messrs. Yarrow had sufficient time to make two other vessels in the contract time, the British Admiralty took over these vessels and sent them out to the Chinde Mouth under the escourt of H.M.S. Redbreast.

I well remember Messrs. Yarrow launching the first pontoon on the Thames, and fitting up the vessel with their boilers and engines in, if I remember rightly, 6½ hours from the time the first pontoon was launched to the time she was under weigh under her own steam, this was the Mosquito, if my memory serves me right.

In conclusion I was the engineer of the James Stevenson, and was present at Chinde when the Herald and Mosquito were launched in sections from H.M. Transport—and put together on the river without landing any part, and we steamed up the Chinde into the Zambesi proper under the escort of H.M.S. Redbreast, Capt. Kerry in Command. Had Major Serfa Pinto opened fire or fired another blank shot from his fort at the juncture of the two rivers, it would have meant war between England and Portugal.

I am Sir, Yours faithfully,
"An Old Mud Larker."

September 28, 1924.

OSMUNDS.

To the Editor of Engineering.

Sir,—If we look in an ordinary English dictionary we shall see under the word "osmund" that it is the name of a flowering plant, and we shall find no other osmund of any kind mentioned. This seems strange, for we know very well that there was another and very different osmund well-known in England, and which for hundreds of years was bought and sold in the metal trade and used freely for many purposes.

If we turn to the great Oxford English Dictionary which, in a large measure, gives all medieval and later words, we shall find, not only a reference to the plant, but many references extending over many centuries to an osmund of metal. The osmund with which we are concerned was the pig or ingot of iron fresh from the smelting works of northern Europe. It was exported to England and elsewhere in bundles or barrels. Several of these small metal bars remain to-day, the shape being very much like a big nail. The osmund was about 10 in. in length and somewhat less than 1 in. in thickness in its stoutest part.

The osmund appears to have been of a finer grain and of a much smoother surface than the large English pig. It appears to have been of a very high quality and was used for the making of the more delicate and finer articles of iron.

Naturally, being of a better quality than the ordinary English iron, the osmund commanded a higher price and consequently offered a special attraction to unscrupulous metal dealers. The system such people commonly adopted was to mix a number of real osmunds with other pieces of inferior metal cast in a similar form and to sell all together as real osmunds.

The accompanying illustration shows a still existing Swedish osmund. The original may be seen in a case in Bay XVI of the new building of the British Museum at Bloomsbury. It is not easy to fix the date of this example, for apparently osmunds retained the same form for some centuries.

Yours, &c.,
H. Littlehales.

27, Eastgate-street, Winchester.

"Dredging and Land Reclamation."—Erratum—In our article on this subject, by a typographical error it was stated, at the bottom of column 2 and the top of column 3, on page 437, of our last week's issue, that the cost of the dredging referred to was ½*d.* per cub. yard; this should read 1*s.* 8*d.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—The quantity of Cleveland pig iron available for sale in the open market is by no means large, but values continue to show rather marked downward tendency, notwithstanding reports of more numerous inquiries. Competition for orders is very keen and actual transactions are only put through after much bargaining. Continental iron is still underselling the products of this district in markets abroad. No. 1 Cleveland pig, though very scarce, is not more than 86*s*. Sellers endeavour to fix the price of No. 3 g.m.b. at 81*s*., but as low as 80*s*. has been accepted. No. 4 foundry is put at 79*s*. 6*d*. and No. 4 forge at 79*s*.

Hematite.—The statistical situation of the East Coast hematite branch is unsatisfactory. With output in excess of current needs, the already heavy stocks at makers' yards are being steadily increased. Quotations are unattractive to customers abroad and home requirements are vastly below what could be desired. Nos. 1, 2 and 3 are put at 89*s*., and No. 1 is quoted sixpence above mixed numbers.

Foreign Ore.—Foreign ore is not much inquired after, but sellers are inclined to take a slightly firmer stand. Market rates remain on the basis of best rubio at 21*s*. 6*d*. c.i.f. Tees.

Blastfurnace Coke.—Local consumers of Durham blastfurnace coke purchase very cautiously. Good average qualities are quoted 25*s*. 6*d*. delivered to users in this district.

Manufactured Iron and Steel.—Sheet makers are busily employed and report good inquiries still circulating, and a few orders for rails are understood to have been secured, but in most branches of the manufactured iron and steel industry underselling by Continental firms has to be faced and business is very difficult to put through. A good deal of foreign semi-finished steel is coming here. Common iron bars are 12*l*. 10*s*.; iron rivets, 14*l*. 5*s*.; packing (parallel), 9*l*.; packing (tapered), 12*l*.; steel billets (soft), 8*l*. 10*s*.; steel billets (medium), 9*l*.; steel billets (hard), 9*l*. 10*s*.; steel rivets, 14*l*. 15*s*.; steel boiler plates, 13*l*. 10*s*.; steel ship, bridge and tank plates, 10*l*. 5*s*.; steel angles, 10*l*.; heavy steel rails, 9*l*.; fish plates, 13*l*.; and galvanised corrugated sheets (24 in. gauge, in bundles), 18*l*. 10*s*.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—Depression is all too general throughout the steel industry of Scotland, and none of the works are employed at anything approaching their actual capacity. The improvement at the shipyards some time ago has not been reflected in the local steel works on account of the cheap material offered from the Continent, as a goodly quantity of the latter is being consumed here. The sheet makers are the best off at present; orders for light gauges are sufficient to ensure steady running for some months yet, and there is quite a fair tonnage of the heavier gauges being turned out. The export demand for galvanised sheets in particular is keeping up very well. Prices are steady, and show no variation over the week, and are quoted as follow:—Boiler plates, 13*l*. 10*s*. per ton; ship plates, 10*l*. 5*s*. per ton; sections 10*l*. per ton; and sheets, $\frac{1}{4}$ in. to $\frac{1}{8}$ in., 12*l*. 10*s*. per ton, all delivered Glasgow stations.

Malleable Iron Trade.—The West of Scotland malleable-iron trade has shown little movement during the past week, and business is as quiet as ever. Neither home nor foreign buyers exhibit any desire to place business, and only actual requirements are being covered in the meantime. The demand is so slow that only a part of the plant in any of the works is able to be kept employed, and that only intermittently. Prices are unaltered with "Crown" bars quoted at 12*l*. 10*s*. per ton delivered at Glasgow stations.

Scottish Pig-Iron Trade.—There is no change in the Scottish pig-iron trade this week, and a very dull tone prevails. Home buyers are still holding off and the foreign demand is almost dead at the present time. Hematite is slow of consumption because of the quietness in the steel works, while foundry grades are also in poor request. Prices are again weaker and show a decline this week. The market quotations are as under:—Hematite, 4*l*. 15*s*. per ton, delivered at the steel works; foundry iron, No. 1, 4*l*. 15*s*. per ton; and No. 3, 4*l*. 10*s*. per ton, both on trucks at makers' yards.

Scottish Pig-iron Shipments.—The shipments of Scottish pig-iron from Glasgow Harbour continue small, and for the week ending last Saturday, September 27, the total was only 866 tons. Of the amount 809 tons went overseas, and 57 tons coastwise. For the corresponding week of last year the shipments were 1,170 tons for foreign destinations and 185 tons coastwise, making a total of 1,355 tons in all.

Shipbuilding.—The returns issued in connection with the Scottish shipbuilding industry for the past month are again very interesting, and point to quite a fair amount of activity in the yards. The output figures for the different districts are as follow:—

	Sept., 1924.		Nine Mths., 1924.	
	Vsls.	Tons.	Vsls.	Tons.
The Clyde	17	44,772	165	375,657
The Forth	1	113	13	23,971
The Tay	1	6,500	6	12,400
The Dee & Moray Firth	3	970	16	11,879
Totals ...	22	52,355	200	423,907

While the above totals are very good and over the average, they are a long way short of the record figures, but the disappointing thing is that there are few new contracts booked on which to commence now. The men are working better and more steadily.

The output figures for the Clyde for the month of September are barely as high as for the previous month, but are a good average and bring the nine months' total up to 165 vessels of 375,657 tons, which compares favourably with recent years, but is still a long way behind the record nine months (1920), when the figures were 166 vessels of 489,425 tons. New orders reported during the month were few and the total in tonnage was not heavy. Amongst the latest are the following: An oil-tank steamer for the Vacuum Oil Company, to be built by the Greenock Dockyard Company; a river steamer for service in the East to be built by Messrs. Yarrow and Co.; and a twin-screw tug, a stern-wheel steamer, and two barges to be constructed by Messrs. Alley and McLellan (Limited), Polmadie, Glasgow.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—The position of the Welsh steam coal trade shows no sign of improvement. In fact, the only classes of coal for which the demand about balances the supply are anthracite, sized coal and best dry large. All other grades are abundantly offered, despite the loss of production caused by pit stoppages, and prices are entirely a matter of individual bargaining with buyers able to secure heavy concessions on the quoted values. Already a score of pits have been closed down, and thousands of men rendered idle, in fact, in the Merthyr district alone it is estimated that 10,000 men are idle or under notice. Colliery salesmen are pressing contractors to take deliveries, and practically the whole of the coal being shipped from the Welsh docks at present are contract supplies. New business is so limited that it is believed that unless a change for the better takes place, half the Welsh pits will be idle by Christmas. This, notwithstanding a considerable reduction in outputs. Nominally, best Admiralty large coal is round 27*s*. 6*d*., with Monmouthshires from 23*s*. 6*d*. to 25*s*., and smalls from 10*s*. to 15*s*., but all these figures can be lowered by buyers with definite business. Best dry large, however, is steady, at 26*s*. 6*d*. to 28*s*., but ordinaries are plentiful at 24*s*. 6*d*. to 25*s*. Anthracite coals are virtually unattainable with French nuts up to 65*s*. The outlook is, indeed, gloomy.

Iron and Steel.—Exports of iron and steel goods last week amounted to 8,591 tons compared with 10,372 tons a week earlier. Shipments of tinplates and terneplates totalled 4,695 tons against 7,200 tons; blackplates, 2,101 tons against 1,599 tons; galvanised sheets, 990 tons against 1,071 tons, and other iron and steel yards, to 779 tons against 502 tons.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Hopes are entertained of an early settlement of the dispute which has reduced the greater part of the basic steel trade of this district to a state of paralysis. The strike of semi-skilled operatives for improved rates and conditions at the three largest concerns devoted to this class of production has now lasted six weeks. Loss in output is reliably estimated at 105,000 tons, and some eight thousand men affected are calculated to have sacrificed 84,000*l*. in wages. Unless an early settlement is reached there is a positive danger that one of three works concerned may have to remain closed for an indefinite period, orders having gone elsewhere. The decision arrived at in Sheffield to reduce the basis of foundry coke from 20*s*. 6*d*. to 16*s*. 9*d*. a ton minimum, superior qualities to be graded proportionately according to calorific value, will benefit iron producers, many of whom have for several weeks been operating unprofitably. Whether the benefit will be passed on in full measure to steelmakers remains to be seen. Reports received from the steel manipulating sections are the reverse of cheerful. Order books generally reflect spasmodic buying in tonnages that leave a big percentage of productive capacity idle. Forges and foundries are similarly placed, though an improved tonnage is going to certain of the shipbuilding yards. Automobile builders continue substantial buyers of special steel and constructional parts, but turnover would, it is stated, be about one-third as large again if the McKenna Duties had not been allowed to lapse. The tool sections are moderately employed, mining and quarrying requisites representing a large share of current output.

South Yorkshire Coal Trade.—Best quality house coal represents the only active section, and though the gross demand still falls short of output, recent advances are maintained. The steam coal market is suffering from the continued slump in the demand from Continental buyers, and with home requirements restricted, prices tend to sag. Best quality slacks are still in request for inland consumption, but cobbles and nuts have developed fresh weakness owing to the abundant offer of inferior grades, and supplies are available at an average reduction of two shillings. Quotations:—Best branch handpicked, 32*s*. to 35*s*.; Barnsley best Silkstone, 26*s*. to 28*s*.; Derbyshire best brights, 26*s*. to 28*s*.; Derbyshire best house, 23*s*. to 25*s*.; Derbyshire best large nuts, 21*s*. to 25*s*.; Derbyshire best small nuts, 13*s*. to 15*s*. 6*d*.; Yorkshire hards, 20*s*. 6*d*. to 22*s*.; Derbyshire hards, 20*s*. to 21*s*. 6*d*.; Rough slacks, 12*s*. 6*d*. to 15*s*. 6*d*.; Nutty slacks, 12*s*. to 14*s*.; Smalls, 6*s*. to 8*s*. 6*d*.

NOTICES OF MEETINGS.

THE INSTITUTE OF TRANSPORT.—Monday, October 6, at 5.30 p.m., at the Institution of Electrical Engineers, Victoria Embankment, W.C. 2. Presidential address by Sir Lynden Macassey, K.B.E., K.C.

THE SOCIETY OF ENGINEERS (INCORPORATED).—Monday, October 6, at 5.30 p.m., at the Geological Society, Burlington-house, Piccadilly, W. "Pulverised Fuel," by Mr. E. Kilburn Scott, M.I.E.E.

THE INSTITUTION OF RUBBER INDUSTRY, LONDON AND DISTRICT SECTION.—Monday, October 6, at 8 p.m., at the Engineers' Club, Coventry-street, W. 1. "Sulphur," by Mr. Edward Anderson, A.I.C.

THE BRADFORD ENGINEERING SOCIETY. Monday, October 6, at 7.30 p.m., in the Hall of the Bradford Technical College. Address by the President, Mr. Baldwin, on "A Visit to the Redcar Steel Works." (With cinema illustrations.)

THE JUNIOR INSTITUTION OF ENGINEERS, NORTH WESTERN SECTION.—Monday, October 6, at 7.30 p.m., at the Manchester Geographical Society, 16, St. Mary's Parsonage, Manchester. Annual General Meeting. Chairman's address, "Triumph over Difficulties."

THE MANCHESTER METALLURGICAL SOCIETY.—Tuesday, October 7, at 7 p.m., in the College of Technology, Manchester. Presidential Address by Mr. J. Cartland, M.C., M.Sc.

THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.—Tuesday, October 7, at 5.30 p.m., at the Royal Society of Arts, John-street, Adelphi, W.C. 2. "Recent Development in the Art of Cracking," by A. E. Dunstan, D.Sc., F.I.C., F.G.S.

THE NEWCOMEN SOCIETY.—Wednesday, October 8, at 5.30 p.m., at the Iron and Steel Institute, 28, Victoria-street, S.W. 1. "A Sketch of the Industrial History of the Coalbrookdale District," by Mr. Rhys Jenkins. "The Discoveries of the Darbys of Coalbrookdale," by Mr. T. S. Ashton, M.A. "Notes on Coalbrookdale and the Darbys," by Mr. John W. Hall.

THE INSTITUTION OF ENGINEERS-IN-CHARGE.—Wednesday, October 8, at 7.30 p.m., at St. Bride's Institute, Bride-lane, Fleet-street, E.C. 4. "The Testing of Aero-Engines in Flight," by Mr. R. J. Penn.

THE OPTICAL SOCIETY. Thursday, October 9, at 7.30 p.m., at the Imperial College, Imperial Institute-road, South Kensington, S.W.7. "Some Problems in the Theory of Optical Diffraction," by Mr. E. T. Hanson B.A. "The Annealing and Re-annealing of Glass." by Mr. W. M. Hampton, B.Sc., A.I.C.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, October 10, at 7.30 p.m. Ordinary meeting. "The Design of Static Sub-stations, with Some Notes on their Equipment," by Mr. N. Thornton.

THE PROCEEDINGS OF THE INSTITUTION OF MECHANICAL ENGINEERS.—We have received Vol. I of the Proceedings of the Institution of Mechanical Engineers for 1924. This contains the papers read in the period from January to May, which have already been dealt with in our columns. The papers included are: "Wave Transmission of Power," by Mr. H. Moss; "Flywheel Stresses," by Mr. A. J. S. Pippard; "Mechanical Engineering in the Military Service," by Major Martel, D.S.O., R.E.; "Repair and Upkeep of Pneumatic Tools," by Mr. R. W. Wilson; "Air Consumption of Internal-Combustion Engines," by Mr. H. Moss; "Irrigation Pumping Machinery, Sudan," by Mr. R. W. Allen; and "Payment by Results," by Mr. J. P. Udal. In addition, Professor A. H. Gibson's and Lieut.-Colonel E. Kitson Clark's lectures to the Graduate Section are given, as well as reports on the joint meetings held with the Chemical Engineering Group and with the Institution of Civil Engineers. The third report of the Steam Turbine Nozzles Research Committee is also included.

ELECTRIC SUPPLY FOR ADEN.—The Executive Committee of Aden Settlement having obtained a licence under the Indian Electricity Act to supply electricity in the Settlement and Cantonment of Aden, have had a scheme prepared by their Consulting Engineers and Agents, Messrs. Barry, Wolfe Barry and Messent, of 2, Queen Anne's Gate, Westminster, London. The scheme put forward by them has been adopted and will be financed by means of a loan obtained from the Government of Bombay. High pressure three-phase alternating current will be generated by 6,600 volts, 50 cycles, and will be transformed down for supply to consumers in the shape of 3-phase 4-wire alternating current at 230 volts per phase. The maximum charges to consumers which are permissible under the license are (1) for general supply purposes for lights, fans and heaters, six annas a unit; (2) power purposes, four annas a unit, with a minimum monthly charge in each case of Rs. 3-8-0 per month The tender of Messrs. Cromptons, Limited, for the power house and its plant has been accepted by the Executive Committee. The tender provides for the installation of three Vickers Spearing boilers and three 250 kw. turbo-alternators together with the necessary subsidiary machinery, and calls for delivery at Aden in eight months. The turbines will be manufactured by Messrs. W. H. Allen, Sons and Co., Limited, and the alternators by Messrs. Crompton and Co., Limited. A managing engineer will shortly be appointed and will probably visit Aden later in the autumn to investigate the transmission and distribution system on the spot. It is hoped that the scheme will be in operation by September, 1925.

REID-MACLEOD GEARED STEAM TURBINE LOCOMOTIVE AT THE BRITISH EMPIRE EXHIBITION.

CONSTRUCTED BY THE NORTH BRITISH LOCOMOTIVE COMPANY, LIMITED, ENGINEERS, GLASGOW.

(*For Description, see Page* 475.)

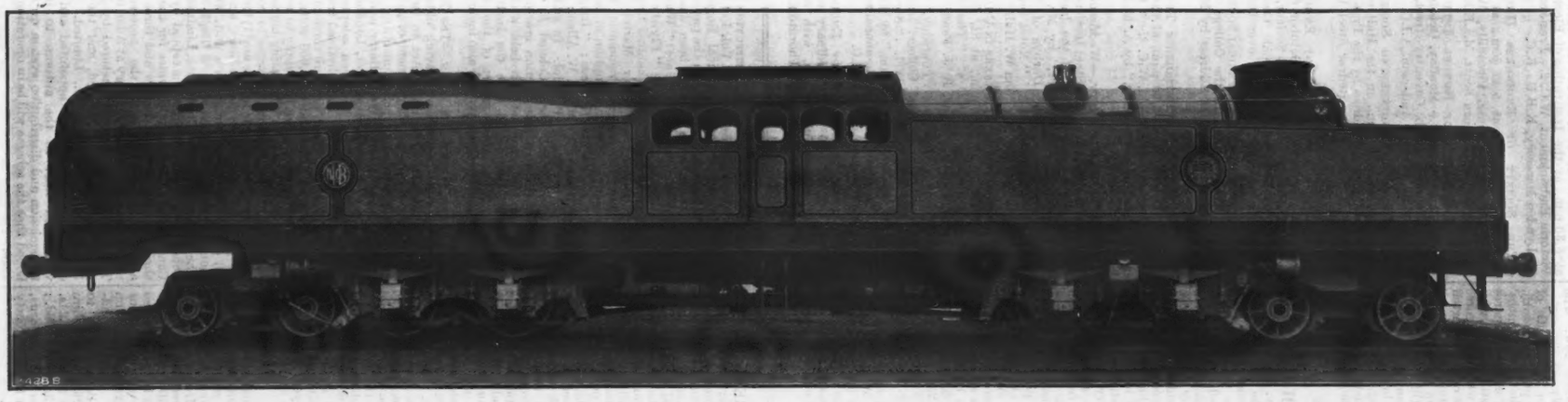


Fig. 188. General View of Locomotive.

Fig. 189. Interior of Cab; Fireman's End.

Fig. 190. Interior of Cab; Driver's End

Fig. 189. Interior of Cab; Fireman's End.

Fig. 190. Interior of Cab; Driver's End

ROYAL SALOON COACH FOR H.M. THE KING OF EGYPT; THE BRITISH EMPIRE EXHIBITION.

CONSTRUCTED BY THE METROPOLITAN CARRIAGE, WAGON AND FINANCE COMPANY, LIMITED, ENGINEERS, BIRMINGHAM.

(*For Description see Page 475.*)

Fig.166.

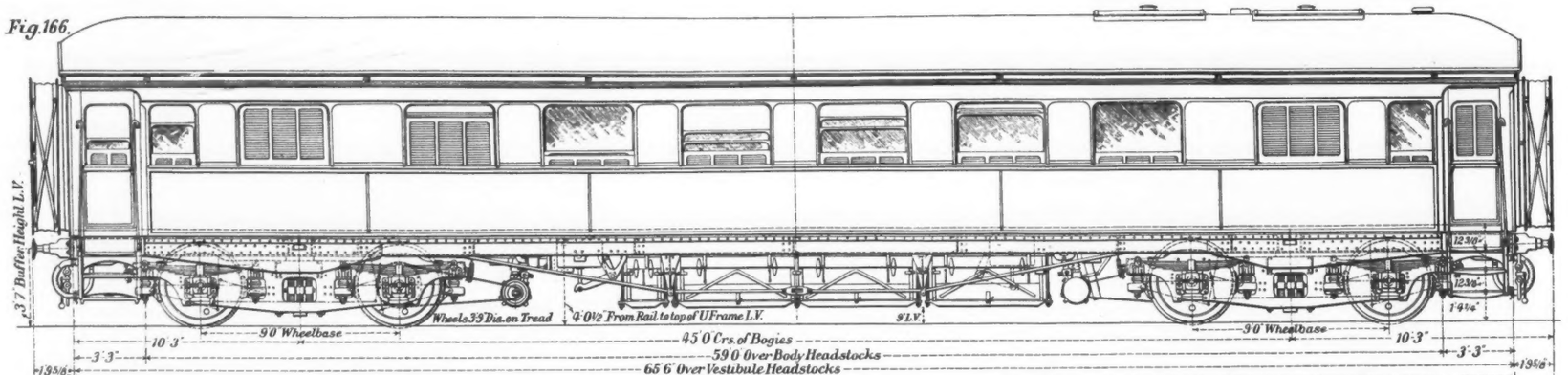


Fig.167.

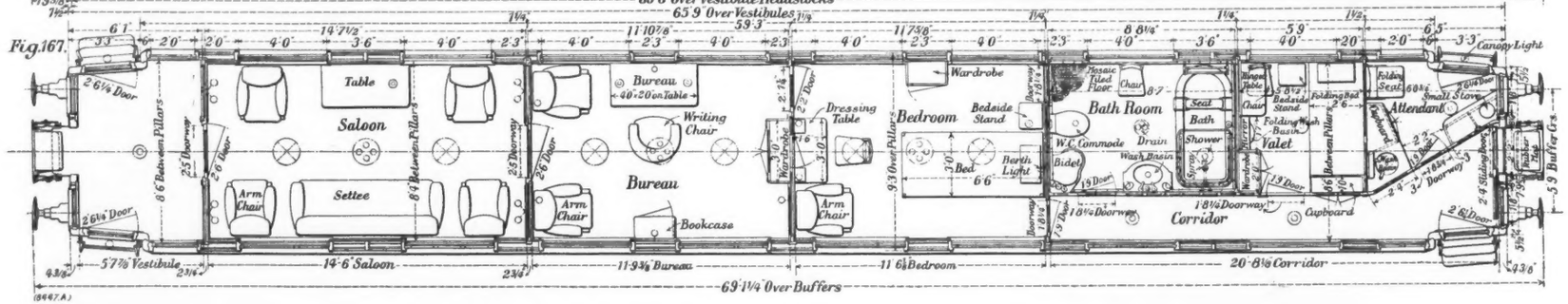


Fig.168.

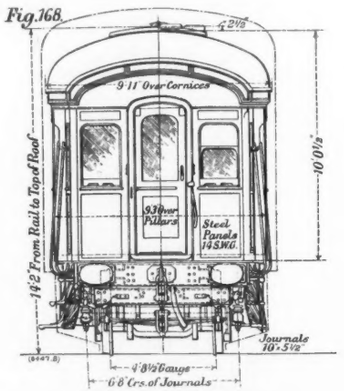


Fig.169.

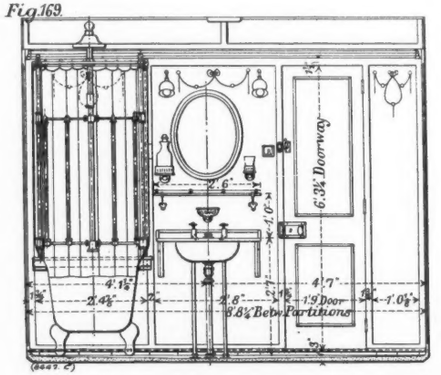


Fig.170.

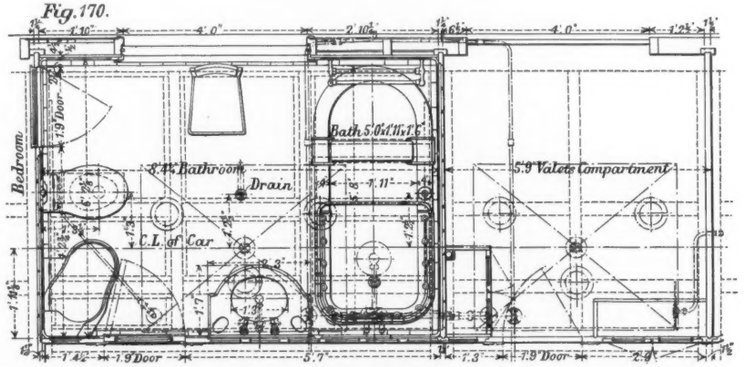


Fig.171.

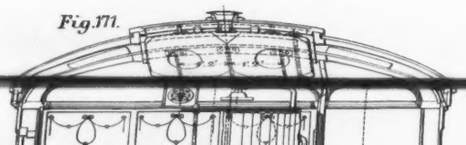


Fig.172.

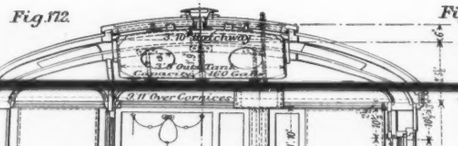
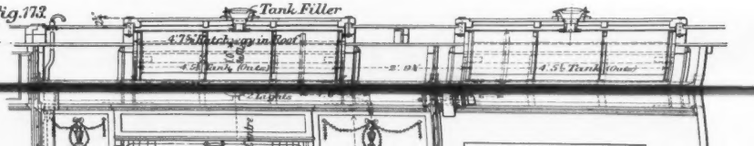


Fig.173.



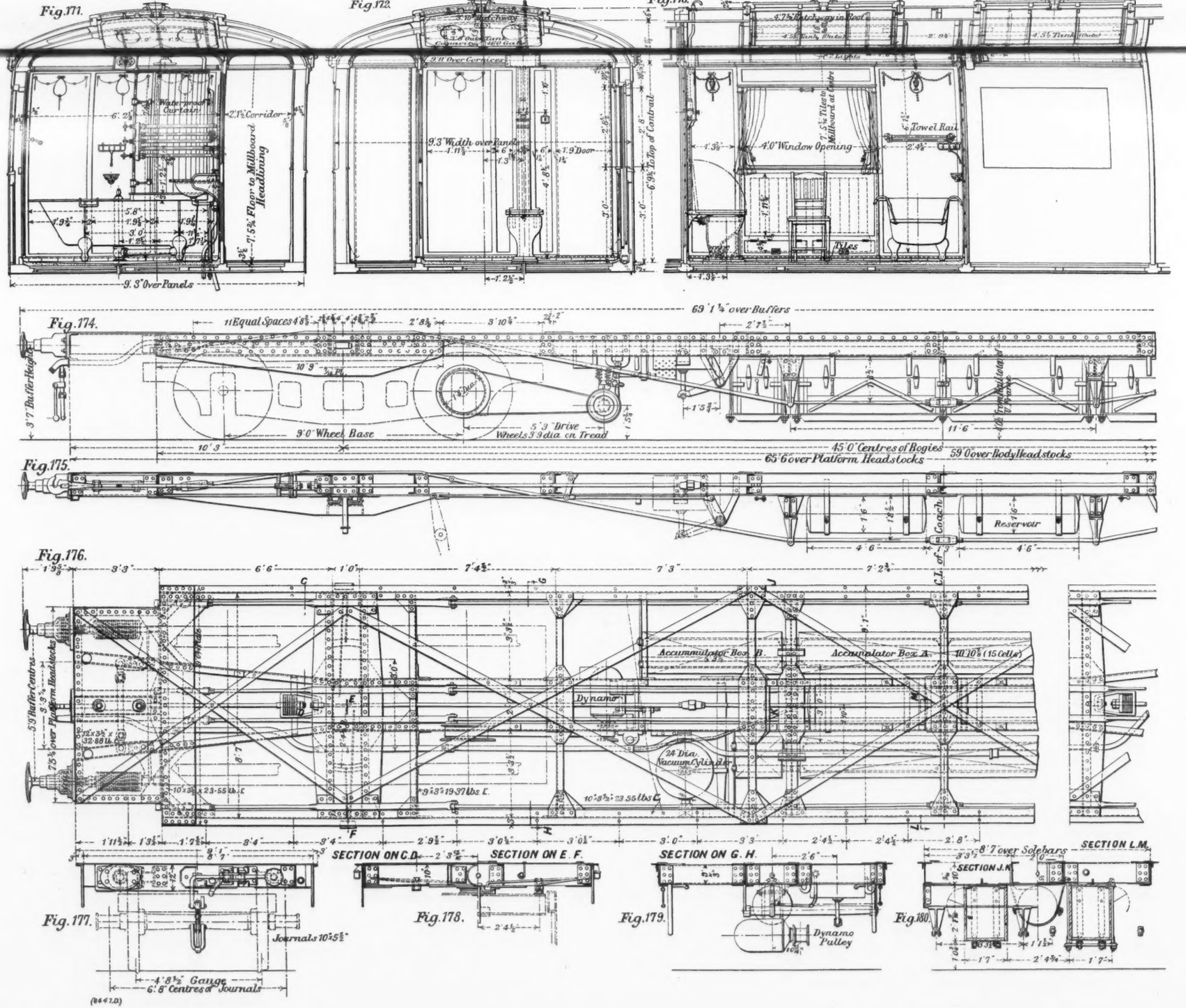


Fig.171.
Fig.172.
Fig.173.
Waterproof Curtain
2'1½" Corridor
7'5¾" Floor to Millboard Headlining
9'3" Over Panels
9'3" Width over Panels
6'9¾" To top of Contrail
4'0" Window Opening
Towel Rail
Tiles
Fig.174.
69'1¾" over Buffers
11 Equal Spaces 4'8⅞"
45'0" Centres of Bogies
3'0" Wheel Base
5'3" Drive
Wheels 3'9 dia. on Tread
11'6"
Fig.175.
65'6" over Platform Headstocks
59'0" over Body Headstocks
Reservoir
Fig.176.
Accumulator Box B.
Accumulator Box A.
Dynamo
Vacuum Cylinder
SECTION ON C.D.
SECTION ON E.F.
SECTION ON G.H.
SECTION J.K.
SECTION L.M.
8'7" over Solebars
Fig.177.
Journals 10½ x 5½"
4'8½" Gauge
6'8" Centres of Journals
Fig.178.
Fig.179.
Dynamo Pulley
Fig.180.

ENGINEERING.

Offices for Publication and Advertisements, 35 and 36, Bedford Street, Strand, London, W.C.2.

We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON.

TELEPHONE NUMBERS—3663 and 8598 GERRARD.

SUBSCRIPTIONS, HOME AND FOREIGN.

"ENGINEERING" may be ordered from any newsagent in town and country and at railway bookstalls, or it can be supplied by the Publisher, post free, at the following rates, for twelve months, payable in advance:—

For the United Kingdom	£3	5	0
For Canada—			
Thin paper copies	£2	18	6
Thick paper copies	£3	3	0
For all other places abroad—			
Thin paper copies	£3	3	0
Thick paper copies	£3	7	6

Foreign and Colonial subscribers receiving incomplete copies through newsagents are requested to communicate the fact to the Publisher, together with the agent's name and address.

When foreign subscriptions are sent by Post Office Orders, advice should be sent to the Publisher.

ADVERTISEMENT RATES.

The charge for advertisements classified under the Headings of Appointments Open, Situations Wanted, Tenders, &c., is four shilings for the first four lines, or under, and one shilling per line up to one inch. The line averages seven words. When an advertisement measures an inch or more the charge is 12*s.* per inch. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

TIME FOR RECEIPT OF ADVERTISEMENTS.

Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity of going to press early with a portion of the edition, alterations for standing advertisements should be received 10 days previous to the day of publication.

All accounts are payable to ENGINEERING, LTD. Cheques should be crossed "The National Provincial Bank, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford Street, Strand, W.C.2.

AGENTS FOR "ENGINEERING."

AUSTRALIA: Gordon and Gotch, Limited, Melbourne; Sydney; Brisbane; Perth. Angus and Robertson, Limited, Sydney, N.S.W. T. Willmett and Co., Townsville, North Queensland. W. C. Rigby, Adelaide, South Australia. Melville and Mullen, Melbourne, Victoria.

BELGIUM, Brussels: E. F. Satchell, 86, Rue du Tabellion.

CANADA, Toronto, Ont.: Wm. Dawson and Sons, Limited, 87, Queen Street, East.

EDINBURGH: John Menzies and Co., Limited, Rose-street.

FRANCE, Paris: Boyveau and Chevillet, 22, Rue de la Banque For Advertisements, Office de Publications Commerciales 167 Rue Montmartre, Paris (2e).

GERMANY: Hermann H. Fromm, Potsdamerstr 105A, Berlin, W. 35. A Twietmeyer, Leipzig.

GLASGOW: William Love, 221, Argyle-street. John Menzies and Co., Limited, West Nile-street.

INDIA, Calcutta: Thacker, Spink and Co., Bombay; Thacker and Co., Limited.

ITALY: U. Hoepli, Milan. Anonima Libraria Italiana, Torino, And any post office.

LIVERPOOL: Mrs. Taylor, Landing Stages.

MANCHESTER: John Heywood, 143, Deansgate.

NEW ZEALAND: Gordon and Gotch Proprietary, Limited, Wellington, Auckland and Christchurch.

NORWAY, Christiania: Cammermeyer's Boghandel, Carl Johans Gade, 41 and 43.

ROTTERDAM: H. A. Kramer and Son, Limited.

SOUTH AFRICA: Central News Agency, Limited, Head Office—Johannesburg; and Pretoria, Cape Town, Port Elizabeth, Bloemfontein, Durban, and various branches and bookstalls throughout South Africa. Wm. Dawson and Sons (South Africa), Limited, 20, Long-street, Capetown.

TASMANIA: Gordon & Gotch Prop'ty, Ltd., Launceston: Hobart.

UNITED STATES: For Subscription, New York: W. H. Wiley, 440, Fourth Avenue. For Advertisements: J. S. Allan, 30, Church-street, New York.

CONTENTS.

	PAGE
The Proportioning of Impulse Blades and Nozzles (*Illus.*)	473
The Aberdeen-Laxapana Hydro-Electric Scheme, Ceylon (*Illus.*)	473
British Empire Exhibition: Railway Material.—VII (*Illus.*)	475
The British Association Meeting at Toronto	480
Electrically Equipped Kitchens on Trains (*Illus.*)	480
The Refractory Section of the Ceramic Society	481
The Worthington 2-Cycle Double-Acting Diesel Engine (*Illus.*)	482
Accidents on the Railways of Great Britain in 1923	484
The Late Mr. R. F. Grantham	486
Letters to the Editor.—"Rotating Discs of Conical Profile." Light-Draught River Vessels. A Rapid Evaluation of Brinell Hardness. Osmunds	486
Notes from South Yorkshire	487
Notes from Cleveland and the Northern Counties	487
Notes from the North	487
Notes from the South-West	487
Notices of Meetings	487
The Relativity of Wages	489
Aircraft Development in the United States	490
Mathematics for Engineers	491
Notes	491
Interferometers for Calibrating Standards of Length (*Illus.*)	491
High-Tension Rectifying and Transmitting Valves (*Illus.*)	492
Labour Notes	494
Books Received	496
Diagrams of Three Month's Fluctuations in the Prices of Metals	496
The Bassler Liquid Meter (*Illus.*)	497
Five-Stage Air Compressor (*Illus.*)	498
The Effects of High Temperature on the Range of Repetition Stresses on Steel	500
Oil-Fired Cochran Boiler (*Illus.*)	501
Copper Ore in Finland	501
Electric Capstan (*Illus.*)	502
Catalogues	502
Outstanding Features of Swedish Practice in Steam Power Production	503
ENGINEERING Patent Record (*Illus.*)	504

Two-Page Plate.—ROYAL SALOON COACH FOR H.M. THE KING OF EGYPT: THE BRITISH EMPIRE EXHIBITION.

ENGINEERING.

FRIDAY, OCTOBER 3, 1924.

THE RELATIVITY OF WAGES.

THE most potent cause of industrial unrest is a sense of injustice. Man wants but little here below for his contentment, provided that he is not confronted too insistently with the sight of someone else who has more. Even then, if he sees that the graduations of wealth characteristic of all ordered civilisations are in rough relationship with ability, energy, or services rendered to the community, his discontent with his own lot is sublimated, as the psychologists would say, into a laudable ambition to improve it. It is the feeling that others, no more meritorious than himself, have taken advantage of the structure of society to secure for themselves more than a fair share of this world's goods, and that, in consequence he is contributing to their welfare at the expense of his own, which engenders bitterness of mind. The present industrial system, under which workers are organised into distinct groups, the members of each group receiving equal wages, regardless of their individual energy or skill, is essentially unfair to those who work with more than the average efficiency, whether they are civil servants or road-sweepers. But as this equality of wages is, generally speaking, insisted on by the workers themselves, its demoralising effects are accepted by them as preferable to alternative evils, and the system does not give rise to industrial unrest in the ordinary sense. The latter arises acutely when one group of workers sees another group enjoying higher wages with no justification for them either in the skill or arduousness of their occupation. The aggrieved group never suggests that the wages of the others should be lowered, but requires that their own should be raised, and to enforce this demand will precipitate all the miseries and losses of an industrial struggle.

Those who maintain that industrial disputes can be settled in accordance with the principles of abstract justice and without recourse to the arbitrament of force, have yet to determine in what justice consists. Should a patternmaker, for example, receive more for a day's work than a moulder, or a blacksmith than a policeman? Before the war certain rough ratios between the payment of the various kinds of skilled and unskilled labour had become accepted, though it was difficult to see how the ratios were justified except by the powers of the respective unions to enforce them. The commonsense of the public, however, accepted them as reasonably fair, they made all trades sufficiently attractive to ensure the required influx of workers and, generally speaking, gave no serious cause for complaint. But the social and industrial changes brought about as a consequence of the war have produced a state of affairs which no one can regard without misgiving. What correlation there once existed between the skill of an occupation and the wages earned seems to have totally disappeared. We find porters better off than mechanics, tram-drivers earning more than cabinet-makers, and in general labourers possessed of no skill or training drawing higher pay than accomplished craftsmen. The injustice of this is obvious, and unless things are rectified the end will be the ruin of those skilled trades by which alone the population of this country is supported.

Even a cursory examination of the facts is sufficient to show, not that the situation is chaotic, for it is not, but that the classes of men who are getting less than a fair wage can be separated, along a fairly well defined line, from those who are getting more than their economic value. As a rule the relatively extravagant wages are found in unskilled or semi-skilled occupations, which could be carried out by almost anybody with a few days' training. This fact, although serious in its moral and industrial effects, is only incidental. It is not, of course, because certain classes of men are unskilled that they can extract unduly high wages, but because their work is of such a nature that it is not subjected to foreign competition. Furthermore in very many cases, these wages are not paid out of the earnings of an industry, but are derived from rates and taxes. The recipients claim them as necessary to provide a certain desirable standard of living, and secure them either by their power at elections or by holding the community at ransom by a strike. The skilled mechanic upon whose work our export trade, and therefore our whole industrial existence depends, has no such resources at his disposal. He does not elect his paymasters at the polls, and as they can only pay wages out of their own earnings, it is futile for him to strike for more than an economic wage, however much he may desire to improve his standard of living. It is no wonder that the skilled man is dissatisfied when he sees ordinary labourers far better off than he is, or that he emigrates to the factories of our foreign competitors where his skill is appreciated at its proper value.

In considering the question of wages in its broadest aspect, it is evident the population of this country cannot enjoy more wealth than it produces. It may live upon its past earnings for a limited period, but in the long run an excess of consumption over production will result in starvation, as certainly for a nation as for an individual. It is no good for a community to decide that it will have a higher standard of living if it has not produced more to live upon. Nature takes no account of resolutions or aspirations, but facts alone. We are enormously poorer than before the war, and our national productivity is less, on account of shorter working hours and other causes. Until productivity is increased we cannot hope for a greater total income, and until this is attained there is no chance of a higher average standard of living. All we can do in the meantime is to see that the national income is used to the best advantage, and that the workers share in it proportionately to their merits. If one class of them gets more than they really earn another class has to take less. The former are really being subsidised at the expense of the latter. It is the skilled mechanic, the shipwright

and the coalminer who are, in effect, paying the excess wages of the municipal employee, the railway porter and the labourer.

These high wages in the sheltered trades are not only a source of legitimate unrest amongst those whose occupations have not the same artificial protection, but they are a definitely adverse factor to the prosperity of many of the skilled trades. The cost of transport is so absurdly great that the heavy engineering trades, for example, are burdened by charges for freight on raw material and finished products which prevent many an order being obtained, and even so, the transport workers are threatening to demand more. The only way by which these high freight charges can be neutralised is by a corresponding reduction in the mechanics' wages, so that the latter class of men are indirectly paying for the high wages of the transport workers. The mechanics, moreover, have to pay more for every article of their own consumption which is subject to transport charges, and they cannot force up their own wages in the face of foreign competition. Some most instructive figures on the relative rates of wages in the sheltered and non-sheltered trades are given in an article by Mr. Archibald Hurd, entitled "The Tyranny of Trade Unionism," in the October issue of the *Fortnightly Review*. It appears that in April last, the average wage paid to fitters and turners in 16 of the principal districts was 56*s*. 5*d*. per week. Shipwrights on time work only received an average of 48*s*. 7*d*. In contrast with these, the average bricklayer, who is certainly no more skilled than a fitter, but who is in a sheltered trade, received 70*s*. 10*d*. for a 44-hr. week. The road labourers of Shoreditch were paid 66*s*. 10*d*. per week and the refuse collectors employed by the same municipality received 68*s*. 4*d*. per week. There is something grossly wrong about a system under which a skilled tradesman is worse off than a tram driver, a ticket collector, or an ordinary labourer.

Sooner or later something will have to be done to rectify the injustice as between different classes of workers, and the sooner the problem is faced the better. The skilled mechanic is much underpaid in comparison with workers in the sheltered trades, and any reduction in the wages of the latter would not only make his expenses less but would facilitate the raising of his own wages. The country has rejected the idea of extending shelter, by means of tariffs, to those industries exposed to foreign competition, and it is therefore incumbent on the Government to relieve them from the parasitic action of those which are not so exposed. Meanwhile we are losing many of the best and ablest of our craftsmen by emigration, and forcing those who remain to accept a standard of living lower than that of a labourer. An authoritative statement as to the proportion which rates, taxes and transport charges now bear to the total cost of production in any exporting industry would perhaps rouse public opinion to a perception of the injustice of the present wage relationship between the sheltered and the unsheltered trades, and lead to action in the matter. The present conditions are unfair to the best of our workers, conducive to industrial exasperation, and destructive to the welfare of ndustry and all who live by it.

AIRCRAFT DEVELOPMENTS IN THE UNITED STATES.

Following upon the somewhat optimistic review of the situation regarding aircraft developments by Air Vice-Marshal Sir W. Sefton Brancker, the Director of Civil Aviation, at the Congress of the Institute of Transport at Wembley (page 450, *ante*), we have on the other side of the Atlantic, if the reports in the public press are correct, President Coolidge owning himself a firm believer in the future of aircraft for naval purposes and in the passing of the capital ship. It is stated that the President has been greatly impressed by the success of the world flight carried out by the U.S. Army airmen and also by the experiences of the U.S. airship Shenandoah, and these two factors have convinced him that the future is in the air and not on the water. If these are the correct reasons for his faith in aircraft and the disappearance of the capital ship, there will be many of his countrymen ready to contest them. For some time now a large body of naval officers has been urging the modernisation of the U.S. capital ships, pointing out that in actual fighting strength, as against displacement, they fall below the 5-5-3 ratio of the Washington Treaty. These officers, it is stated, have the sympathy and active co-operation of Mr. Wilbur, the Secretary of the Navy, and a former naval officer. There is thus likely to be a sharp controversy between those who take the President's views of the paramount importance of aircraft and the obsolescence of the capital ship and those who take the view that both aircraft and battleships have important and independent rôles in national defence.

So far as the success of the world flight is concerned, this, to the ordinary man in the street, would hardly appear to have the importance with which, it is alleged, the President regards it. Starting on March 17, the flight was completed on September 29, a duration of six and a-half months. Although some time was unavoidably lost in waiting for their leader in the Northern Pacific, yet the time required for the remainder of the flight was prolonged. Difficulties were encountered in various portions of the route and, as an example of physical endurance, the completion of the flight reflects the greatest credit on the three U.S. Army airmen and their colleagues. Credit should also be given to those who organised the flight, for new engines and spare parts were accumulated at the various points of call, and these were largely drawn on. In addition, wherever circumstances permitted, units of the American Fleet were at hand to give all necessary assistance. Such favourable conditions could hardly be expected in actual warfare, and are in striking contrast to the help given by the Government to British aviators who essayed the same flight. Possibly in this lack of support our own authorities demonstrated their view that a world flight was of little value in testing the qualities of aeroplanes for war purposes.

But if the President's reported deduction from the successful world flight is difficult to follow, that on the importance of the airship appears to be based on more solid foundations. The Shenandoah has been in commission for over twelve months and has been uniformly successful. Several remarkable flights have been made, and at least one exciting experience has been safely negotiated. We refer to the airship breaking loose from a mooring mast during a heavy gale, whereby she sustained considerable damage to the structure forward and to one of her fins. Despite this damage, the officers and crew by superb navigation brought her safely to her shed at Lakehurst. This spectacular feat was one which won the admiration and considerably enhanced the value of the rigid airship in the minds of the American public.

More recently the Shenandoah has been engaged in fleet manœuvres and proved her worth by searching for four "enemy" vessels, reporting their position and movements by wireless to the Fleet, and finally "destroying" one of the four. It is not stated if the "enemy" ships carried aeroplanes for defence against such an adversary, thus giving a more equal and realistic touch to the manœuvres. During this flight the airship flew steadily for 40 hours at cruising speed, and, at one period, was 500 miles from the American coast, being 72 hours away from her base altogether.

A few such experiences as these emphasise the value of airships to a fleet, a value which is considerably increased by the fact that the gas by which the Shenandoah secures her buoyancy is helium. As we pointed out some time ago, the use of this gas in place of hydrogen increases to an incalculable extent the safety of an airship, rendering her practically immune from destruction by fire. In the possession of inexhaustible supplies of natural gas from which helium can be obtained, and the necessary appliances for its separation and collection, the United States have a very distinct advantage over other nations.

Another interesting fact which is recorded of the flight of the Shenandoah is that the water-recovery system proved so efficient that it became unnecessary to "valve", or liberate, any helium, although 9,500 lb. of petrol were used during the 72 hours' flight. According to the American technical press, American engineers have been experimenting on this problem for some time, and it would appear that their efforts have been crowned with success.

The operations of the Shenandoah have necessitated a new type of auxiliary war vessel, whose sole representative at the present time is the Patoka, a former oil tanker of about 17,000 tons deadweight, which has been converted to a mobile airship base. This vessel is fitted with a mooring mast at the stern, whose platform is 120 ft. above the deck, and is fitted with a topmast 30 ft. long for wireless purposes. The mast is of the lattice type and has a base 45 ft. square. The Patoka is arranged to stow cylinders in her hold, in which 2¼ million cub. ft. of helium can be compressed. A helium supply main, 1 ft. in diameter, is connected to the gas cylinders and runs up to the platform on the mast. Pipes for the supply of petrol and fresh water are similarly arranged for. Powerful electric lights are fitted on the platform. Three seaplanes are also carried, presumably for defence against air attack. The vessel was originally prepared for the proposed flight of the Shenandoah to the Arctic regions, and, although this was cancelled, the vessel is being retained for service with the fleet. She is thus the first mobile base for rigid airships, and as a test of the arrangements, the Shenandoah was recently moored to the mast for a week.

It is evident from the aeronautical press, that the operations of the Shenandoah have impressed American public opinion and that much is expected of the type of aircraft she represents. One of the leading journals has found it necessary to issue a word of caution in connection with a proposed programme of airship work which, it states, has received official consideration, if not approval. This programme, which is to be put into operation when ZR3, a commercial airship built in Germany, reaches America, includes a world flight by both ships, one proceeding east and the other west; a flight to South America to cement friendly relations between the peoples of North and South America, and to collect geographical, geological, aerological and oceanographical data; exploration of the million square miles area between Alaska and the North Pole; and, finally, a regular mail service between London and New York. The programme, if correct, is an ambitious one, and the journal to which we refer cautions the Government against engaging in it until the capabilities of the two airships have been completely and finally established. As evidence of the belief of the United States authorities in the future of the rigid airship, it has been recently announced that specifications and plans are being prepared by the Navy Department for a super-Dreadnought of the air of dimensions far in excess of those of the Shenandoah. It is stated that the volume of this airship may reach 10 million cub. ft., the speed 85 miles an hour, with a fuel supply sufficient to make the return voyage across the Atlantic.

But whilst the Navy Department is busily engaged in the development of the rigid airship, it is not neglecting aircraft of the heavier-than-air-type. The qualities and operations of all types of naval machines are being continuously improved, and according to reports are in advance of European nations. At the present time only one aircraft carrier—the Langley—is in commission, but others are being pushed forward. Photographs of American warships which are being published in the illustrated papers show that many are fitted with one or more catapults of the revolving type by which aircraft can be started on their flight. This is a contrivance which the United States Navy has been experimenting with for many years, the first having been constructed and tried before the outbreak of the Great War. As it has now been adopted in many of the American warships, it may be concluded that success has been achieved in its construction and use. European nations are far more reticent in allowing photographs or drawings of their warships to be published and information on such matters is treated as confidential. It may be the case, therefore, that catapults are being fitted in the warships of other Powers, although nothing has been allowed to transpire. If this is not so, the United States naval authorities may rightly claim to be in advance in this respect, and their lack of aircraft carriers

is to some extent compensated by the general fitting of catapults on one or two aeroplanes in the larger fleet units. These aeroplanes must be of the amphibian type, since they have necessarily to land in the sea and be hoisted on board by crane or other means. Photographs have also been published of a small seaplane designed for use in a submarine and stowed in cylinders on its deck. By this addition it is claimed the vision of the submarine is very largely augmented. This is, we believe, the first occasion on which aircraft have been so used.

From the foregoing account it may be gathered that at the present time the United States authorities—and especially the Navy Department—is busily, and from all appearances successfully, engaged in developing aircraft for purposes of national defence and for commerce. Unless some special endeavour is made by the British Government, some of those airship services which Sir Sefton Brancker envisaged in his address to the Institute of Transport will be flying the Stars and Stripes in place of the Union Jack.

MATHEMATICS FOR ENGINEERS.

On several occasions during recent years we have pointed out that the object of the engineer in studying mathematics is to provide himself with a useful tool and not as an end in itself. This being so, it is right and proper that he should attack the subject by the methods with which he is most familiar, and on which he must mainly rely in the conduct of his life work, viz., geometrical and mechanical experience and intuition. All the functions with which he is concerned have what Professor Whitehead has called "convenient properties." If they do not possess the latter, they are in the very nature of things useless to him. The methods of proof and attack relied upon by the mathematicians of a hundred years ago, therefore, hold good for all such mathematical questions as may be of interest and importance to him, and are those which should be followed by his teachers. That innumerable continuous functions can be conceived which have no differential co-efficient may interest him in the same way that the more intelligent type of literary man may be interested in learning that it has now proved possible to measure the diameter of some of the fixed stars, but it is placing an undue burden on the engineer to insist that the old time simple proofs of the theorems in which he may be interested, should be remodelled and complicated to meet conditions with which he will never be confronted.

The point of view above set forth formed the text of a paper on "The Teaching of Mathematics to Engineering Students," which Professor Sir J. B. Henderson read before the International Mathematical Congress at Toronto. As stated above, we have repeatedly urged in our own columns, but Sir James has done good service in impressing on a body of professional mathematicians, the unwisdom of increasing the difficulties of the subject to the engineering student by the complications arising from the study of what may perhaps be called fancy functions. These seem for the most part to resemble the average idol of the heathen, in that so far as our present knowledge goes, they represent nothing existing in the heavens above, the earth beneath, or the waters under the earth.

It would seem from a recent review in *Nature* that the physicist is being confronted by much the same difficulty. At Cambridge mathematics and physics have been divorced for some years, a step which was probably inevitable in view of the growth of both subjects.

Nevertheless, the physicist must acquire a good working knowledge of mathematics, and this should be attainable without undue insistence that proofs and demonstrations shall be valid not only in the limited mathematical field in which he is interested, but also throughout the whole of the external area which the mathematicians have filled with non-differentiable functions, which, whilst continuous, cannot be represented by a graph. The tool user should not, in short, be called upon to undergo the same apprenticeship as the tool maker.

The article in *Nature*, to which reference has already been made, observes further that the abandonment of the principle that "the profound study of nature is the most fruitful source of mathematical discoveries" has been followed by a barren period in British mathematics. The principle in question implicitly assumes that mechanical and geometrical intuition are the most effective agents in promoting mathematical progress, and our own national genius lies rather in imagination and intuition than in pure logic. Most of us, in fact, mistrust the latter save within narrowly defined limits. It is true, of course, that in matters mathematical we are masters of our premises, and a purely logical development is, therefore, legitimate, however dangerous it may prove in other studies. What is legitimate, however, is not necessarily wise, and it may well be that, as in Fourier's time, mechanical and geometrical intuition may again play a leading part in the further development of mathematics. In the meantime, it is the faculty on which most reliance should be placed in presenting the subject to engineering students. It is too frequently forgotten that those who use mathematics for practical ends have one safeguard which the pure mathematician lacks. They have to obtain numerical results. This in itself constitutes a not ineffective safeguard against, say, the illegitimate use of a divergent series, and in the second place the result has to be in general accord with practical experience. The engineer's investigations seldom lead him on to entirely novel ground. He can generally find some more or less analogous case, which gives him some rough idea as to what the numerical value should be, and if his calculations diverge too widely from this, he suspects an error in his analysis, and this suspicion generally proves justified.

NOTES.

Smokeless Fuel at Glasgow.

Those who look forward to the eventual development of some commercially satisfactory process for the production of smokeless fuel by the low-temperature carbonisation of coal will be interested in a development which is about to take place in Glasgow. We are interested to learn that the Glasgow Corporation has decided to install a five-unit plant of the type developed by Messrs. Maclaurin Carbonisation, Limited, to work in connection with the large generating station at Dalmarnock. A single-unit Maclaurin plant, capable of carbonising 20 tons of coal per day, was installed at the Port Dundas Generating Station of the Corporation in 1915. This plant, with the consent of the Corporation, was subsequently moved to Grangemouth, where further experiments have since been carried out on a large scale. The success of these has resulted in the decision above referred to, and the new five-unit plant will be in operation within the next few months. The idea is apparently to produce smokeless fuel for domestic purposes with gas as a by-product. The electricity Department are willing to give 1·01*d.* per therm for this gas for boiler-firing, when coal is 20*s.* per ton, and it is said that when the new plant is working it will be profitable to dispose of the gas at this price. It is not stated, in the report to which we refer, that any attempt is to be made to recover oil or ammonia as by-products, the main object being, apparently, the production of smokeless fuel.

The Strength of Hooks.

Experiments made during the war in connection with aeroplane components showed that the ultimate strength of hooks and eyes was not very different from what would have been estimated by the simple formulæ in general use a generation ago. The mathematician has shown us, however, that within the elastic limit, the maximum stress produced in a hook by a stated load, may be very materially higher than would have been estimated from the older formula, and the engineer has been offered as a substitute for this the fairly simple Winckler-Bach formula and the much more complicated Andrews-Pearson formula. Both give results in satisfactory agreement with the complete mathematical theory, but the Andrews-Pearson formula is in conflict with the well-established theorem that in "simply connected" structures the elastic coefficients cannot enter into any expression for plane stress. A new comparison of these formulas with experiments, has recently been carried out at the testing station of the Bureau of Standards, U.S.A. ["Tests of Some Girder Hooks." By Herbert L. Whittemore and Ambrose H. Stang. Technologic Papers of the Bureau of Standards. No. 260. Price 10 cents.] The hooks experimented with were provided by the American Bridge Company, and were of a pattern used for lifting steel girders into place, and had nominal lifting capacities of 5, 10 and 15 tons respectively. As was to be expected, the two formulas above mentioned proved both to give stresses in reasonable accord with those deduced (within the elastic limit) by strain measurements, but with the particular pattern of hook experimented with, the stresses by the old simple theory were not more than 20 per cent. too low. It was found, moreover, that the openings of the hooks when the stress reached the elastic limit were only $\frac{1}{16}$ in. wider than at first, so that it is not possible to tell by mere inspection of a hook whether the material has been strained beyond the elastic limit.

The Panama Canal.

On August 14 last, the Panama Canal had been in operation for ten years, having been officially opened to commerce on August 15, 1914. The outbreak of war interfered with the celebrations planned originally on an international scale. In the ten years which have elapsed no bad accident has occurred to shipping using the waterway, nor has traffic been seriously interfered with since 1916, and, though there has been some trouble from slides in a few instances, in none has there been occasion for any long delay. The number of commercial vessels making use of the canal in the decade, has amounted to 25,620, no less than a fifth of these having passed through in the last twelve months. When a new route is opened to any form of transport, it takes some time for traffic to adjust itself to the new facilities. The Panama Canal, opened during the war, did not get a normal start, and for a while after the war suffered by the World's efforts to resume its normal life. The two most recent years afford proof of the immense value, which this great engineering work is likely to become. The cargo tonnage making the passage of the Canal in 1921 and 1922 reached to between eleven and twelve million tons. The traffic increase since has been phenomenal. In 1923 the Canal passed no less than 21,210,962 tons, while in the year ending August 14, 1924, the tonnage passed was no less than 26,633,477. As trade improves, and the effects of the war pass, a considerable increase on these figures is, of course, to be expected. The value of the Canal to American shipping is to be judged from the fact that in the ten years nearly 11,000 passages were made by United States vessels, which carried roughly one-half of the total cargo. In this connection it must be remembered that the United States got a good start while other countries were concerned with more serious matters than ordinary commerce. However, the Canal was bound to be of immense permanent value to that country, commercially as well as strategically, as the sea route now available affords cheaper transport between the east and west coast ports than was available by rail before. The figures given do not include 2,271 U.S. Government vessels using the Canal in the period named.

INTERFEROMETERS FOR CALIBRATING STANDARDS OF LENGTH.

For some years past engineers have recognised that optical methods provide the most delicate means of standardising lengths, and such methods are now in use in a number of establishments for testing the precision of gauges. Other optical methods have been devised by which accurate standards of length can be originated and during the past few days Messrs. Adam Hilger, Limited, of Camden-road, London, have completed apparatus of this kind to the order of the Japanese Government. The need for such an equipment arose, because the metre has been adopted in Japan as the sole legal standard of length and, although copies of the international standard at Paris are now made

with great accuracy, the Japanese authorities wished to have apparatus by which the residual error in these could be accurately measured, and also to be able to produce other standards of which the length could, with the highest degree of precision, be determined in terms of the Paris meter. An accurate standard reproducible in every part of the globe is represented by the wave-length of the red line of the Cadmium spectrum. It will be remembered that Benoit, Fabry and Perot in 1907 showed that the wave-length of the light represented by this line was $6{,}438{\cdot}4702 \times 10^{-3}$ cm.; a figure which agrees, within 2 units in the last place, with the original determination made by Michelson and Benoit in 1894. The wave-length of this light constitutes, therefore (for all terrestial measurements), an absolute standard of length with which practical measures can be compared and their errors determined.

The Japanese Government accordingly ordered from Messrs. Hilger the apparatus necessary for such a comparison, and we think that an explanation of the principles involved may be of interest.

Using the copy of the metre as a basis, the first operation is to produce a measure which is very nearly 1 metre in length. From this sub-standard another of exactly half the length is derived, the final adjustment to this exact half value being effected by purely optical methods, as will be explained presently. A third standard, half the length of the second, is next produced in the same way, and the process is repeated until a standard exactly one-sixteenth the length of the original sub-standard is obtained. The error in the latter is then determined in terms of the wave-length of Cadmium light, and thus the true length of the whole series is fixed with extreme precision.

These sub-standards each take the form of a cell. (See Fig. 1.) The walls A B and C D consist of two stout bars of invar, and the ends of two optically worked glass plates E. and F. The whole cell is mounted on an invar base plate. The glass end plates are each silvered on their internal faces, but the silver coating is so thin that one half of the incident light passes through, whilst the other half is reflected. It is the distance between these two silvered surfaces which constitutes the sub-standard of length, of which the true value has to be determined in terms of the international meter at Paris. A first determination is made, by ordinary mechanical means, in terms of the official copy of the meter, and hence the optical methods to be described have merely to fix the very small residual error. The next step in the procedure is to make a second cell the length of which is adjusted to be exactly one-half of the distance between the end plates of the first cell. This second cell is of exactly similar construction to the first, and in Fig. 1 the two invar side bars are represented by G H and I J and the two glass end plates by K and L. The length between the internal silvered surfaces of these end plates is made, by ordinary workshop methods, as nearly as practicable equal to one-half the distance between E and F, and is then adjusted to nearly absolute accuracy by optical methods. To permit of this adjustment the glass plates do not rest directly on the ends of the side plates as represented in the diagram, but are fitted with micrometer screws, by which they can be adjusted not merely as to their distance apart but also into absolute parallelism.

The optical test depends upon the fact that when the length of the second cell is exactly one-half that of the first, certain interference effects are produced if a beam of light is passed through both cells when arranged in series as indicated in the diagram. These effects are not detectable if the halving operation described above is inexact.

The test is made in the following way. A beam of white light is passed through the cells from O to Q and is then reflected by a mirror at Q through the *lame étalon* represented at R. This *lame étalon* consists of two plates of glass which are separated from each other by strips of tinfoil at each end. One of these strips is thicker than the other and the air gap included between the two sheets is therefore wedge shaped. When white light passes through such a wedge of air enclosed between glass plates, interference effects are produced exactly in the same way as are Newton's rings when a lens is pressed against a flat glass plate. If, therefore, the two cells E F and K L were removed we should, on viewing the *lame étalon* through the telescope S, see a series of colour bands.

If, however, the apparatus is arranged as in the figure, we shall in general get additional interference effects, due to the fact that whilst some of the light passes once only through the cells, other portions of it are reflected to and fro between the silvered end plates before they finally succeed in escaping to Q. Owing to these reflections, the rays, which finally reach the *lame étalon* at R, have traversed different distances before getting there, and accordingly are not, speaking generally, in phase with each other. The additional interference thus arising causes such an overlapping of the colour bands produced at the *lame étalon* that these mutually destroy each other, and the whole field, as viewed through the telescope S, appears white. The above state of affairs is what results if the length of the second cell is not exactly one-half the length of the first. If, however, the adjustment to this half-

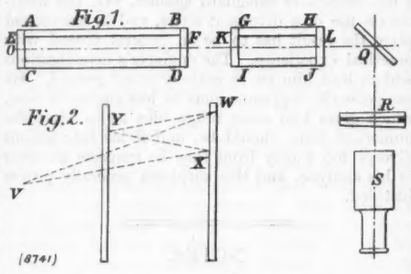


Fig. 1.

Fig. 2.

length is accurately made, some of the light which passes through the two cells, after undergoing different numbers of reflections within them, arrives at R in the same phase. In this case faint bands of colour can then be perceived through the telescope S. The test is a very delicate one, as unless the distance between K and L is exactly right the bands cannot be seen.

The reason will be apparent from the following considerations. Suppose, for example, that the distance between E and F is $n + \theta$ wave-lengths of some particular kind of light, where n represents a whole number of wave-lengths and θ a fractional wave-length. Then with proper adjustment the distance between K and L will be $\frac{n}{2} + \frac{\theta}{2}$ wave-lengths.

Now consider that portion of the light which traverses the first cell once, but which is reflected to and fro in the second cell and only escapes from it after traversing it five times. Then the total distance (within the cells) traversed by this fraction of the light will be $n + \theta + \frac{5n}{2} + \frac{5\theta}{2}$ wave-lengths. Consider next another fraction of the light which only escapes from the first cell after it has been reflected to and fro from the silvered surfaces, and suppose that, owing to these reflections, it has traversed this cell three times. It then passes to the second cell and part of it passes directly through this to Q and on to R. This part will have traversed (within the cells) a total path equal to $3n + 3\theta + \frac{n}{2} + \frac{\theta}{2}$ wave lengths. The difference in the length of the two paths described above is, it will be seen, a whole number of wave-lengths. Hence, both the fractions considered, reach R in the same phase and only suffer interference on passing through the *lame étalon* and thus give rise to faint bands which are visible in the telescope.

The characteristic feature of the device lies in the fact that white light is used, which gives rise to coloured bands, if the only interference is that produced by the *lame étalon*; whilst if additional interference is produced by a faulty adjustment of the lengths of the two cells, the bands overlap so much, that they obliterate each other and the field of view appears white.

By repetitions of the operations above described a cell is at last obtained of which the length is just one-sixteenth of the distance between the plates E and F of the first cell. The actual distance is already known with great accuracy, since the distance between E and F has been measured by a comparator. There is, however, a very small outstanding error, and this is determined by passing a ray of the red light of Cadmium through the cell and measuring the diameter of the rings produced by the interference of rays which have followed different paths before reaching the eye.

The principle involved will be readily understood on reference to the diagrammatic scheme of the apparatus which is represented in Fig. 2. Here the two vertical plates represent the end plates of the cell, whilst V represents a point source of Cadimum light. Consider the point W. One ray of light reaches this point directly, as indicated by the dotted line. Another ray, however, reaches the same point after reflection from the semi-transparent silvered surface of the second of the glass sheets, and after a further reflection from the corresponding surface of the first sheet. Hence, the two rays, which both arrive at W, have followed different paths. If the difference in the length of these paths is exactly half a wave-length the "crest" of the one ray corresponds to a "trough" of the other. The two therefore mutually destroy each other, and a dark Newton ring is produced. If, however, the two paths differ by a whole number of wave-lengths, the two rays reinforce each other and a bright Newton ring is produced.

There is thus a definite geometrical relationship between the wave-length of the light, the diameter of the rings produced, and the distance between the two glass plates. The Newton rings formed are of very small size and they are viewed through a telescope fitted with a micrometer, by which their diameters can be measured with a high degree of accuracy. From these measurements it is possible with the same degree of precision to calculate the error in the distance between the two end plates of the "one-sixteenth" cell, and we then know to an equal degree of precision the dimensions of all the preceding cells.

The methods above described are, it will be seen, simple in principle, but a very high degree of accuracy is required in all the mechanical and optical work as well as considerable ingenuity in devising the various adjustments so as to be at once convenient, sensitive and reliable. It is sufficient to know that the whole of the work has been carried out at the establishment of Messrs. Adam Hilger, Limited, to be assured that these requirements have been most successfully filled.

HIGH-TENSION RECTIFYING AND TRANSMITTING VALVES.

In our last issue, on page 456 *ante*, we described the manufacture of the small three-electrode thermionic valves, used mainly for the reception of broadcast telephony, as carried out at the Brook Green Works, Hammersmith, of the M. O. Valve Company, Limited. We mentioned, in the article referred to, the fact that the firm's products are by no means confined to small receiving valves, but also include a wide range of transmitting valves, as well as valves for rectifying high-tension alternating currents. Notable progress has recently been made in the two last-mentioned applications of the thermionic valve, and we now propose to deal with the latest developments in these directions.

Rectification is, of course, one of the functions of the valves of a wireless receiving set, and was, in fact, the sole object of the two-electrode valve, as first invented and employed by Dr. J. A. Fleming. The addition of the third electrode, or grid, by De Forest, by enabling valves to be used for amplifying extremely weak currents and for generating electrical oscillations of almost any frequency, has so enormously augmented their utility that their employment for simple rectification may seem of comparatively little importance. There are, however, a number of applications in which valves may be used as efficient, convenient and reliable rectifiers, particularly of high-tension currents of moderate strength. Such applications include the supply of the anode current to valves used in wireless telegraphic and telephonic transmitting apparatus, the supply of high-tension direct current for the precipitation of smoke and fumes, for X-ray work, and for the testing of cables. The voltages employed for these purposes range from about 10,000 in the first-mentioned to 100,000 and upwards in the last, and, as will be readily understood, the detail design of the valve is largely dependent upon the pressure at which it is required to work. The principle of operation, however, is the

same in all cases and depends upon the fact that the negative electrons emitted by the heated filament are drawn towards the anode when the latter is at a positive potential with respect to the filament, thus constituting a flow of current through the valve, but when the anode potential becomes negative the electrons are repelled and the current flow ceases. If, therefore, an alternating potential of any frequency is applied to the anode, a pulsating unidirectional current will be produced, the current flowing during that half of each cycle during which the anode is positive and being entirely suppressed during the other half. By suitably connecting a pair of valves, or four valves, both halves of a cycle can be rectified, producing a more steady unidirectional flow.

The design of rectifying valves for the production of a few amperes of direct current at about 10,000 volts, such as is required for wireless transmitting apparatus, presents no great difficulty and many types and sizes are available for the purpose. In the rectification of currents at pressures of the order of 100,000 volts, however, some interesting problems are encountered, not the least of which arises from the electrostatic attraction between the filament and anode; this attraction, of course, varies as the square of the operating voltage. The conditions, however, have been satisfactorily met by the M. O. Valve Company, Limited, in the valve illustrated in Figs. 1 to 3 above, this valve being suitable for rectification at pressures up to 150,000 volts, and being capable of passing a current of about 100 milliamperes, R.M.S. value. The filament requires a heating current of 8 amperes at 8 volts.

In this valve the anode, which can be seen in position in Fig. 1, and is illustrated separately in Fig. 3, consists of a molybdenum cylinder, closed at one end and flanged in at the other, so that when mounted in the valve it encloses the filament system as completely as possible. The latter, which is illustrated in Fig. 2, consists of two nearly circular loops connected in parallel and mounted in vertical planes at right angles on the forked ends of the two lead-in wires. Where the filaments cross, they are connected to a central support insulated by steatite. The whole arrangement of the filaments, which is clearly shown in Fig. 2, has been adopted to reduce to a minimum the distortion which would normally occur from the electrostatic attraction between the anode and filament during that part of the cycle in which the valve is non-conducting. The partially-closed anode is used so that the electronic current will be kept as far as possible to the interior of the anode, there being, in these circumstances, a much smaller tendency for any residual gas in the bulb to become ionised. The glass is also largely protected from the electronic bombardment, with the result that the stability of the vacuum is increased. It is also an advantage, as regards the vacuum, if the total amount of heat generated in the bulb is kept small, and the short and unimpeded path provided for the electron stream with the arrangement of filament and anode adopted, has the effect of lowering the effective resistance of the valve and thus of reducing the heat production. It is found in practice with this type of valve, that should the vacuum become impaired by accident or improper use to an extent sufficient to give rise to obvious signs of gas discharge, the rectification is still almost complete. The valve can thus often be kept in action until the released gas has been again adsorbed on the walls of the bulb.

The small size of the filament system also ensures that, in the non-conducting phase, when the full operating voltage is applied to the valve in the reverse direction to the current flow (or twice the operating voltage when bi-phase rectification is employed), there is a steeper potential gradient outside the positive electrode, which is the filament at this part of the cycle, and consequently a less steep gradient outside the negative electrode. If, therefore, the anode system is made smooth and free from sharp edges, so as to avoid local steep-potential gradients, the operating voltage can be raised very high before there are any signs of point discharge. This somewhat obscure phenomenon is caused by an extremely intense, but very localised, emission of electrons from those parts of the negative electrode, whether hot or cold, where potential gradients of the order of 1,000,000 volts per centimetre exist. It is only by giving attention in the design to such matters as have been mentioned above that rectifying valves can be made to operate satisfactorily with the extra-high voltages required for cable testing and other similar work.

The use of the three-electrode valve as a generator of oscillations for wireless transmitting apparatus has developed enormously in recent years, but the high powers used in modern stations have resulted in a demand for units of larger capacity than have hitherto been generally available. The capacity of the ordinary valve, in which the electrodes are totally enclosed in a glass bulb, is limited, by the difficulty of dissipating the heat generated in the anode by the electronic bombardment, to about 2 kw., and, although it is possible to employ a large number of valves working in parallel, there are obvious objections to this course on account of the space occupied, the fragility of the large glass bulbs, &c. Practically the whole of the heat is radiated from the anode to the glass walls of the bulb, which has thus to be made inconveniently large in order to prevent it from softening, or at least from becoming sufficiently hot to impair the high vacuum required for satisfactory working. The anode itself must, of course, be made from a metal, such as molybdenum, having a very high melting point, so that it can withstand the extremely high temperatures attained in working.

The obvious method of disposing of the heat generated in the anode, and thus of avoiding these difficulties, is to employ water cooling, but although the advantages of this method of cooling have been appreciated for some years, it is only comparatively recently that valve manufacturers have been able to devise satisfactory means for applying it in practice. One of the chief difficulties, as will be readily understood, was to ensure a permanently vacuum-tight joint between the metal anode and the glass required to serve as an insulating support for the other electrodes. The difficulties, however, now appear to have been satisfactorily overcome, and water-cooled valves are being made in different parts of the world and are coming into more general use.

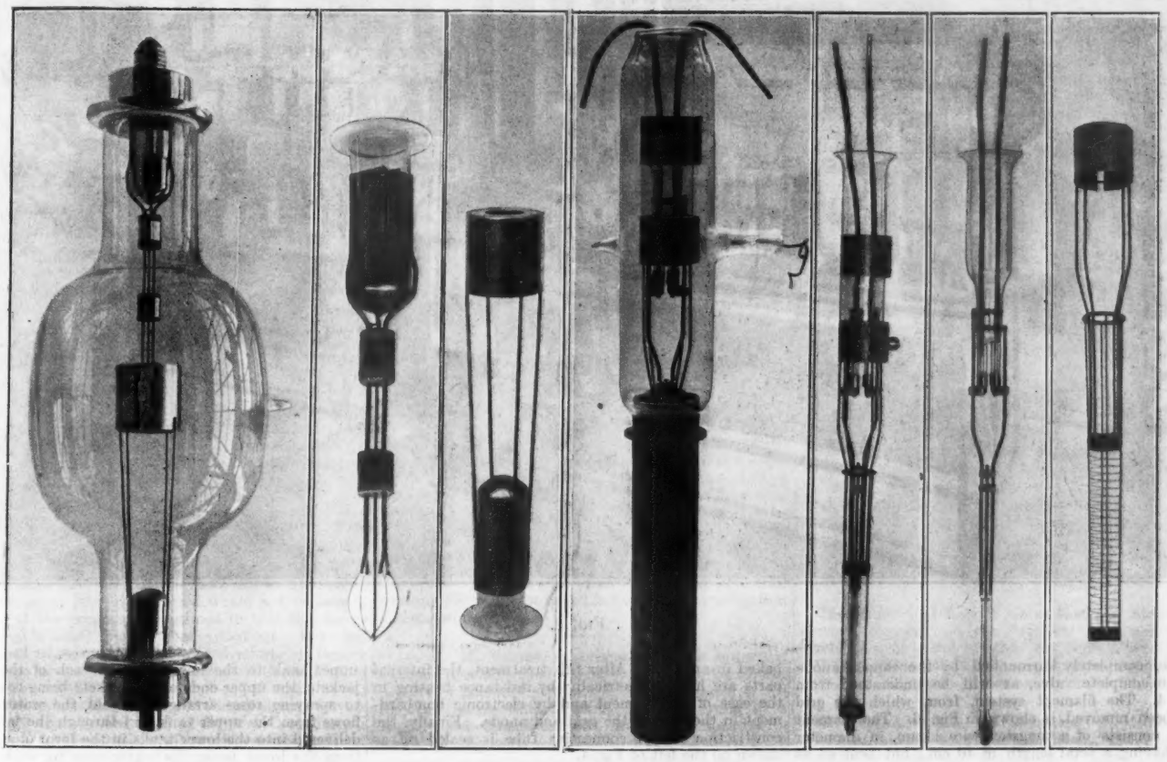


Fig. 1. Fig. 2. Fig. 3. Fig. 4. Fig. 5. Fig. 6. Fig. 7.

Figs. 1 to 3. High-Tension Rectifying Valve and Components. Figs. 4 to 7. Water-Cooled Transmitting Valve and Components.

Fig. 4 shows a water-cooled valve manufactured by the M.O. Valve Company, Limited, which is capable of absorbing over 12 kw., with an anode voltage ranging from 15,000 to 18,000 on a dead-loss test, *i.e.*, when oscillations are not being produced in the external circuits. When oscillating, an input of 30 kw. at 15,000 volts has been reached, although the normal load is from 10 kw. to 15 kw. input, the loss by heat generated in the anode then amounting to about 3 kw. In Fig. 4, the valve is shown complete, except for the water-jacket which surrounds the anode when the valve is in use. The anode, which occupies the lower half of the illustration, consists of a copper tube 5 cm. in diameter externally and 23 cm. in length, closed at the lower end, and having a ring of a special nickel-iron alloy brazed on to its upper end, on to which a glass tube 7 cm. in diameter is fused. The nickel-iron ring has the same coefficient of expansion as glass, and thus does not set up strains in the latter due to changes in temperature. To obtain perfect adhesion between the glass and metal, however, the nickel-iron ring is coated with a thin film of copper before making the joint. The filament and grid system, which is shown in Fig. 5, is supported on a flanged glass tube, the latter being fused into the previously open end of the larger glass tube which is sealed on to the anode. The grid and filament are, of

APPARATUS AT THE CHELMSFORD BROADCASTING STATION.

CONSTRUCTED BY MARCONI'S WIRELESS TELEGRAPH CO., LIMITED, ENGINEERS, CHELMSFORD.

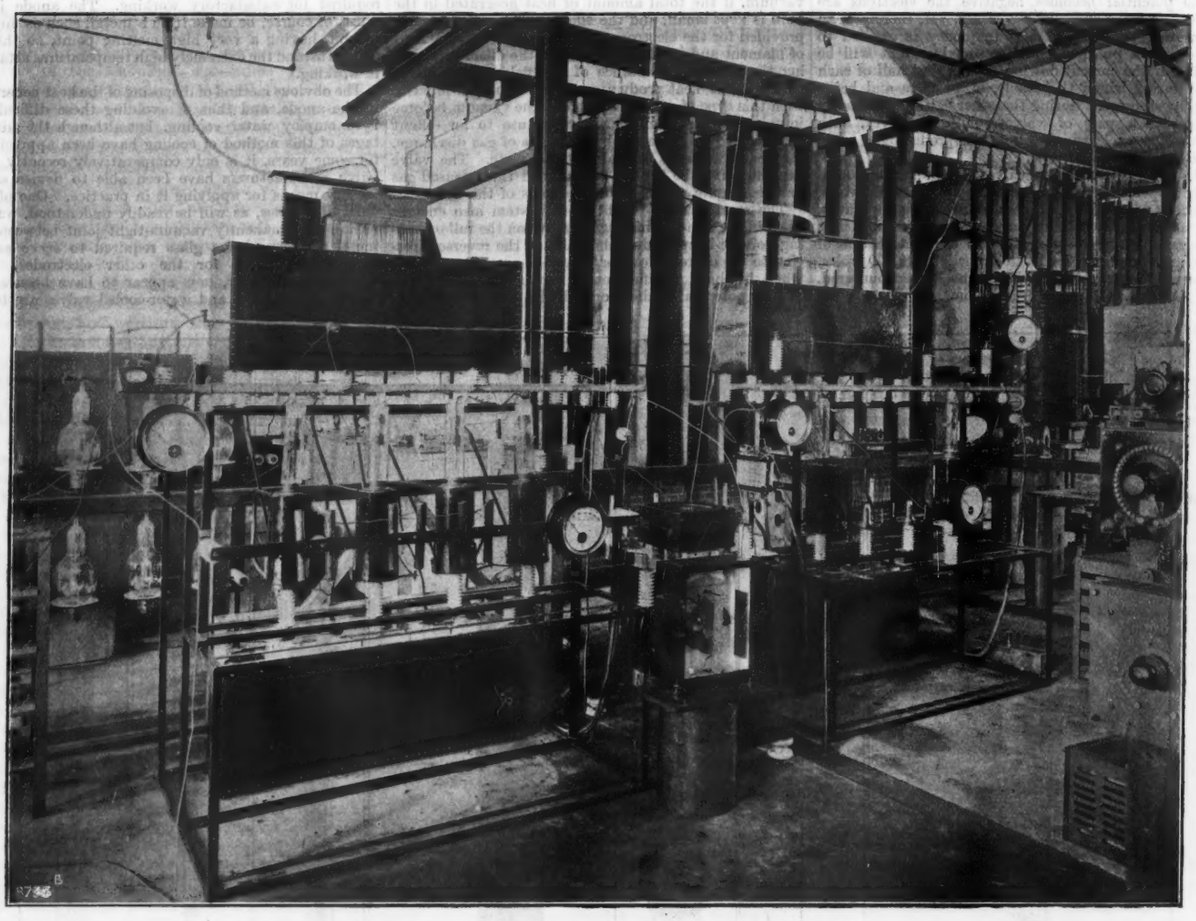


Fig. 8.

course, completely surrounded by the copper anode in the complete valve, as will be understood from Fig. 4. The filament system, from which the grid has been removed, is shown in Fig. 6. The filament itself consists of a tungsten wire 1 mm. in diameter and having a total length of 40 cm., but bent so as to form two U-shaped loops, each limb of which is about 10 cm. in length. The leads and the central support for the filament are of molybdenum, and the heating current required is about 50 amperes at 20 volts. Trouble is experienced in conveying such a heavy current through the glass by solid leads in the ordinary way, and, to avoid this, thin thimbles, to which the connections are made, are sealed into the glass, as is most clearly shown in Fig. 6. The grid system, which is also supported on the glass seal as can be seen in Fig. 5, consists of a "stocking" woven from fine wire and supported by four tungsten rods, the whole being carried by four rods brazed on to a clamp. Mica is used to insulate the grid system from the filament, while electrical connection to the former is made through the side of the glass enclosing tube, as will be clear from Fig. 4. Fig. 7 shows the form of grid employed when the valve is used as a modulator, the form illustrated in Fig. 5 being that adopted when the valve is used for generating oscillations.

Every part of the electrodes inside the valve has to be designed so as to avoid sharp corners and projections, which would set up the point-discharge mentioned above in describing the high-tension rectifying valve. Special precautions have also to be taken to ensure the cleanliness of the internal parts, as traces of grease or dirt would, of course, impair the vacuum. A side tube with a constriction is used to connect the valve with the pump for exhaustion. This operation has to be carried out very thoroughly, and in order to free the parts from gases the complete valve is baked in an oven. After this treatment, the internal parts are heated electrically, by resistance heating in the case of the filament and by electronic bombardment in the case of the grid and anode. Finally, the constriction in the connecting tube is sealed off as shown on the left of Fig. 4.

It may be of interest to refer, in conclusion, to the use of these valves at the high-power experimental station, 5 XX, of the British Broadcasting Company, designed by Marconi's Wireless Telegraph Company, Limited, and erected at their Chelmsford works. A photograph of the transmitting apparatus at this station is reproduced in Fig. 8 on this page, and four water-cooled valves of the type described above can be seen on the left of this illustration mounted in an angle-iron framework. These valves, which handle about 5½ kw. each, are employed for modulating the oscillations generated by two other valves of the same type, which can be distinguished towards the right of the illustration; the input to each of the oscillator valves is 11 kw. The anodes of all the valves are supplied with rectified alternating current at 10,000 volts, and some of the rectifying valves can be seen on the extreme left of Fig. 7. These rectifying valves, it should be mentioned, are of the M.R. 7A type and are not of the extra-high tension type described above. Other components of the apparatus, such as the aerial condensers and an electrostatic voltmeter for indicating the anode voltage, can be recognised in the illustration.

The chief interest in the latter, however, centres round the water-cooling arrangements for the modulating and oscillating valves which can be followed by examining the illustration closely. It will be seen that the angle iron frame of each set supports a pair of steel tanks, one above the level of the valves carried on porcelain insulators and one below them close to the ground. Separate pipe connections are led from the upper tank to the lower ends of each of the water jackets, the upper ends of the jackets being connected to spraying roses arranged so that the water which flows from the upper tank and through the jackets is delivered into the lower tanks in the form of a spray; from the lower tanks the water runs to waste. The water supply from the mains to the upper tanks is also delivered through sprays, the object of these sprays being to break the water up into separate drops and thus to disconnect the tanks electrically from the earth. The need for this precaution arises from the fact that the water in the jackets is at the potential of the anodes, viz., 10,000 volts, and, although clean water is not a good conductor, some leakage of current would take place if the sprays were omitted. Further to increase the resistance of the path to earth, lengths of rubber tubing are included in the pipes connecting the upper tanks to the water jackets, and also in those connecting the jackets to the outlet spraying nozzles.

The Chelmsford experimental station has now been in operation for some months, mostly transmitting the evening programmes from the London broadcasting station on a wave length of 1,600 metres, the same programmes also being transmitted simultaneously, on a wave length of 365 metres and on the usual power, from the London station. The Chelmsford station has a normal range of 100 miles for crystal reception, but has been heard, under favourable conditions, over a distance of 1,000 miles with the same form of receiving apparatus. It has recently been announced that the British Broadcasting Company hopes to establish a permanent high-power station within the next six months, to be located probably in the neighbourhood of Northampton. Presumably the transmitting apparatus now in use at Chelmsford will be transferred to the new station, as it appears to have functioned quite satisfactorily.

LABOUR NOTES.

NOBODY who is aware of the facts which Sir Robert Hadfield graphically expressed in his letter to *The Times* seeks to deny that the state of matters to which they relate is deplorable and ought to be ended in some such way as Sir Robert indicates. An industrial truce arrived at in the manner proposed by Mr. G. N. Barnes will be, however, not so easy to bring about as is suggested. A conference of representative employers and trade unionists was held, it will be recalled, some time after the Armistice with the object of setting up a national joint body, which would have functioned as a sort of Industrial Parliament. That attempt to find a basis of common understanding in the Labour affairs of the country failed largely because some of the executives hesitated to pledge their unions to action of any kind. One or two—the Amalgamated Society of Engineers, as it then was, amongst them—actually withdrew. Mr. Barnes suggests that either the General Council of the Trades Union Congress or its opposite number on the employers' side—presumably the Confederation of Employers' Organisations—should invite the other to a conference on the subject. The experiment is certainly worth trying, and if it succeeded in setting up a Court of Reference that commanded the confidence of both sides—a Court, that is, to which all differences that threatened to lead to stoppages would be referred—great good would be the result.

The fact must not be ignored, however, that one of the most cherished rights of trade unionists is the right to strike. Up till now, they have emphatically declared against compulsory arbitration and insisted on the right to strike in the last resort. Under their various agreements with the Engineering Employers Federation, the engineering unions have retained it for use after the provisions for avoiding disputes have been exhausted. Still, even if only national provisions for avoiding disputes with their local and central facilities for discussing differences were the result of such a conference as Mr. Barnes proposes, the community would be immensely the gainer, for stoppages are nine times out of ten the result of misunderstandings or distrust and nothing clears away both so effectively as frank and free discussion.

Judging from the circular which has been issued to all the branches of the metal and metal-working trades unions by the Metal Workers Section of the National Minority Movement, the idea of the Red International Labour Union is to destroy industry as at present organised and substitute a dictatorship of the proletariat. The officially-defined attitude of the executive committee of the Labour Party towards the renewed application of the Communist Party for affiliation suggests that a dictatorship of the proletariat here is not an immediate possibility. But the destruction of industry as at present organised would not be long in coming if the programme outlined in this circular of the Metal Workers' Section were carried out. Branches are urged to make "a great united effort" to secure (1) a wage advance of 20*s.* 0*d.* per week with an ultimate minimum—whatever that means—of 4*l.* per week; (2) a 44-hour working week, and the abolition of overtime; (3) the establishment of Factory Committees; (4) control by the unions of all youths and apprentices. Even under a dictatorship of the proletariat any industry obliged to feed and clothe its workers and their dependdants would speedily go to the wall were its "conditions" the least like that.

While our workers are seeking directly and indirectly to increase production costs Continental workers, especially in Germany, are acquiescing in measures which tend enormously to reduce them. According to the Federation of Trades Unions 82·4 per cent. of textile employees and 68·5 per cent. of metal employees work longer than eight hours per day. A third of these metal employees work more than 54 hours per week. In the heavy iron and steel trades ten hours a day is the rule. In the chemical and printing trades the eight hours' day has been largely abandoned, although in the building, wood and footwear trades large majorities adhere to it. In all trades the longest hours prevail in big concerns. Up to the end of 1923 the rule in coal mining was 7 to 7½ hours per day for men working underground, and 8 hours for men working on the surface. At present in all districts, except the Saar, the rule is 8 to 8½ hours underground, and 9½ to 10 hours on the surface. The same hours obtain in lignite and iron ore mining. The longer hours have resulted, it is stated, in a great increase of output and consequent decrease in working costs. In most cases the ratio of increase in production exceeds the ratio of increase in working hours.

Mr. A. B. Swales, the new Chairman of the General Council of the Trades Union Congress, is a Yorkshireman who has been on the executive council of the Amalgamated Engineering Union—formerly the Amalgamated Society of Engineers—since 1917. For a year or two previously he was Organising Delegate in the London District. He is this year's fraternal delegate of the British Trades Union Congress, to the Convention of the American Federation of Labour. Mr. Swales is a blacksmith, but is not the first of his craft to achieve distinction in his organisation. The late Mr. Alfred Sellicks, who was chairman of the executive council of the old A.S.E. in the late 'nineties of last century and a singularly able administrator, was also, if our memory serves, a blacksmith.

At its annual conference in Blackpool the National Federation of Building Trade Operatives decided to recommend the withdrawal of affiliated societies from the Wages and Conditions Council. The settlement of the recent dispute is not affected by this decision. It stands by itself and continues in force until 1926. According to Mr. Coppock, the resolution means that a new method of negotiation will have to be set up to take the place of the Wages and Conditions Council, and he hopes that that will be done between now and next March when the necessary six months' notice which the Federation has just given expires.

In his presidential address to the annual conference of the Institute of Industrial Welfare Workers which met at Swanwick, Derbyshire, on September 27 and 28, Mr. A. C. Marshall, of Sheffield, referred to the disappointment felt at the results of the shorter working day, and said that the general lack of co-ordinating effort throughout industry was responsible. It was essential in his opinion if we were to go on holding our own, that we should put our industrial house in order. The race was to the nation which was organised industrially in a highly efficient and yet in a thoroughly human way.

At its opening session the conference discussed "What the Psychologist can do for Industry." Dr. C. S. Myers, Director of the Institute of Industrial Psychology, in an address, spoke of the importance of rest pauses in factories and other industrial concerns, and gave statistics showing that in one experiment a reduction of 3 per cent. in working hours resulted in an increased output of 5 per cent. He emphasised on the other hand, the bad effect on production of excessively short hours, and said that in certain classes of the boot trade experiments had indicated—although the results seemed to need further investigation—that the rate of production progressively fell after the hours of labour had been reduced below forty hours a week. In future, there would be, he said, a close association between the welfare worker and the industrial psychologist. As the education of the welfare worker became more complicated, some knowledge of industrial psychology and physiology would be necessary. The main difference would be that whereas the function of the welfare worker would be to observe, the industrial psychologist would be called in for action, investigation and experiment.

Dr. H. M. Vernon, investigator for the Industrial Fatigue Research Board, dealt with the physiological aspects of accident prevention. In the course of his remarks, he mentioned that it had been found by a Home Office Committee that in all the industries in which investigations were made, accidents were more numerous in winter-time, when there was a good deal of artificial light, than in the summer-time, when there was little or none. Undoubtedly, considerable fatigue had increased the frequency of accidents, but it seemed probable that under ordinary working conditions the physiological state of the workers was much more important a factor in accident causation than physical fatigue. The increase of accidents as the result of the speeding-up of production was probably more physiological in its origin than psychological. The atmospheric conditions under which industry was carried on might, Dr. Vernon suggested, have a great influence on the frequency of accidents. In one factory experiment it had been found that there was a minimum of accidents when the temperature was 65 to 69. When the temperature fell 5 deg. there were 6 per cent. more accidents. Another 5 deg. lower, accidents increased by 16 per cent., while another drop in the temperature of 5 deg. involved a 35 per cent. increase in the number of accidents. At temperatures above 69 deg. accidents again increased in frequency. One very obvious and simple means of decreasing mining accidents was to improve the ventilation of mines.

Addressing the Rowntree Conference of Managers and Foremen at Oxford on September 27, Mr. Ernest Bevin, Secretary of the Transport and General Workers' Union, said that the specialisation of labour to-day prevented the workman from viewing his industry as a whole. Some method must be found to teach him exactly what his industry meant to the nation and to the world. There need be no fear that such a movement would tend to produce revolution or violent changes in any form. The workmen were nearly as conservative as the employers. At this moment they were at the cross-roads. Within the next five years this country, as well as others, must either drift towards a general upheaval, or must give the workman his proper place in industry. He wanted to see the State itself set up an economic council of impartial men and women who would examine the factors which composed industry, take into account the new psychology of the workers, and investigate how far industry to-day was thwarted by the dead hand of the past. As long as there remained the conception that an industry was wholly the possession of those who contributed its capital, he saw no way of interesting the workers in industry.

According to the Central Statistical Board, the number of days actually worked in Soviet industry in 1920 was 228·3. In 1921 the number was 221·5; in 1922, 257·9; and in 1923, 260·7. The number of holidays in 1923, including Sundays and summer holidays, was 81. The total number of hours worked in industry in 1923 was 1,948, as compared with 3,100 in Czarist Russia. Apart from rectifying faults of organisation leading to unnecessary loss of working time (which in 1923 amounted to 186·4 hours), the Soviet authorities are striving, *Russian Information and Review* states, to make good this difference, not by long hours of work and reduction of legitimate holidays, but exclusively by improving the methods of organisation and intensity of labour.

The wages of British railwaymen, which fluctuate with the cost of living, are to remain at their present level for the next three months. On September 29, the Central Wages Board decided that recent movements of the index do not warrant any immediate readjustment of the scale of pay.

The Umpire under the Unemployment Insurance Acts has decided that the stoppages at the Rischow and Camerton Collieries, Cumberland, were due to the employers terminating all contracts with their workmen. He has, therefore, granted the men full benefit as from August 1.

The Industrial Court has issued its reserved decision in the reference concerning the wages of charge hands and men on night duty employed by The Metropolitan Water Board. An extra allowance for the leading drivers at the different pumping stations in Kent is awarded, the amount varying from 5*s.* per week to 2*s.* 6*d.* per week. Only men who are on the rotative system were affected by the claim for night work payments. In their case, the rates already fixed by the Court are inclusive rates, and the Court decide that where men are so employed, no extra payment falls to be made.

The Ministry of Labour states that the number of persons recorded on the registers of Employment Exchanges in Great Britain on September 22 was 1,180,200. This was 16,250 more than on September 15, 1924, but 105,423 less than on December 31, 1923.

On September 29, the Industrial Court heard a reference relative to wages submitted by the London County Council and the Joint Trades Tramways Movement. The wages of the Council's employees of this class are regulated broadly on the basis of the wages agreed to by employers' associations and trade unions or, in the absence of "agreed" rates, on the basis of those in practice obtaining. In 1922, when the Engineering and National Employers' Federations put into operation three cuts of 5*s.* 6*d.* per week each, the London County Council, after a lapse of time, operated only two cuts of 5*s.* 6*d.* per week, and in July of the present year they restored one of these cuts, leaving their employees with a war bonus of 21*s.* per week, as against the bonus of 10*s.* per week paid by members of the Federations. The unions asked that the other cut of 5*s.* 6*d.* should also be restored, and they based their claim partly on the practice of the London borough councils and on the higher rates paid by the London General Omnibus Company and by the tramways connected with the "Combine." The men affected are in the Chief Engineer's Department (main drainage, &c.), Mental Hospitals, Fire Brigade, and Tramways Department, and number in all about 1,200. It is estimated that the cost to the Council of conceding the claim would be 17,500*l.* per annum, of which 12,800*l.* would fall on the tramways. Sir William Mackenzie, who presided, intimated that the Court would take time to consider its decision.

At a meeting in Manchester on September 30 the short-time organisation committee of the Federation of Master Cotton Spinners' Associations decided that the existing working hours of 26½ a week should be adhered to, and that there should be another review of the situation on October 7.

BOOKS RECEIVED.

La Méthode Générale des Sciences. Pures et Appliquées. By André Lamouche. Paris: Gauthier-Villars et Cie. [Price 30 francs.]

Across the Sahara by Motor Car: From Touggourt to Timbuctoo. By Georges Marie Haardt and Louis Audouin-Dubreuil. Translated from the French by E. E. Fournier d'Albe. London: T. Fisher Unwin, Limited. [Price 12s. 6d. net.]

The Thermionic Valve and its Developments in Radio-telegraphy and Telephony. By J. A. Fleming, M.A., D.Sc., F.R.S. Second edition. Revised. London: The Wireless Press, Limited. [Price 15s. net.]

Thermionic Tubes in Radio Telegraphy and Telephony. By John Scott-Taggart, F.Inst.P. Second edition. London: The Wireless Press, Limited. [Price 15s. net.]

The Calculation and Measurement of Inductance and Capacity. By W. H. Nottage, B.Sc., F.Inst.P. Second edition. London: The Wireless Press, Limited. [Price 7s. 6d. net.]

The Kinetic Theory of Gases. By Eugene Bloch. Translated by P. A. Smith, B.A. London: Methuen and Co., Limited. [Price 7s. net.]

Anleitung zur Berechnung einer Dampmaschine. By R. Grassmann. Berlin: Julius Springer. [Price 6·70 dols.]

United States Bureau of Standards. Circular No. 74. *Radio Instruments and Measurements.* Second edition. [Price 60 cents.] No. 158. *United States Government Master Specifications. Surfacing Materials for Bituminous Built-up Roofing.* [Price 5 cents.] No. 159. *Asphalt for Mineral-surfaced Roofing.* [Price 5 cents. No. 162. *Asphalt Primer for Roofing and Waterproofing.* [Price 5 cents.] Technologic Papers No. 253. *Standardisation of Hosiery Box Dimensions.* By C. W. Schoffstall and E. M. Schanke. [Price 10 cents.] Washington: Government Printing Office.

Theorie und Berechnung dei Eisernen Brücken. By Dr.-Ing. Friedrich Bleich. Berlin: Julius Springer. [Price 9 dols.]

Moderne Metallkunde in Theorie und Praxis. By J. Czochralski. Berlin: Julius Springer. [Price 2·85 dols.]

The Theory of Relativity, Studies and Contributions. By A. Henderson, A. W. Hobbs and J. W. Lasley, jun. Chapel Hill N.C.: University of North Carolina Press. London: Humphrey Milford. [Price 11s. 6d. net.]

The Design and Working of Ammonia Stills. By P. Parrish, A.I.C., M.I.Chem.E. London: Ernest Benn., Limited. [Price 40s. net.]

United States Geological Survey. Mineral Resources of the United States. I: 19. *Copper in* 1922. (*General Report.*) By H. A. C. Jenison. I: 22. *Gold, Silver, Copper, Lead and Zinc in Utah in* 1922. *Mines Report.* By V. C. Heikes. I: 23. *Gold, Silver, Copper, Lead and Zinc in California and Oregon in* 1922. *Mines Report.* By J. M. Hill. I: 24. *Gold, Silver, Lead and Zinc in Montana in* 1922. *Mines Report.* By C. N. Gerry. I: 25. *Gold, Silver, Copper, Lead and Zinc in Arizona in* 1922. *Mines Report.* By V. C. Heikes. I: 26. *Gold, Silver, Copper, Lead and Zinc in Colorado in* 1922. *Mines Report.* By C. W. Henderson. I: 27. *Cobalt, Molybdenum, Nickel, Tantalum, Titanium, Radium, Uranium and Vanadium in* 1922. By F. L. Hess. Washington: Government Printing Office.

A Century of Sea Trading, 1824–1924. *The General Steam Navigation Company, Limited.* By L. Cope Cornford. London: A. and C. Black, Limited. [Price 10s. 6d. net.]

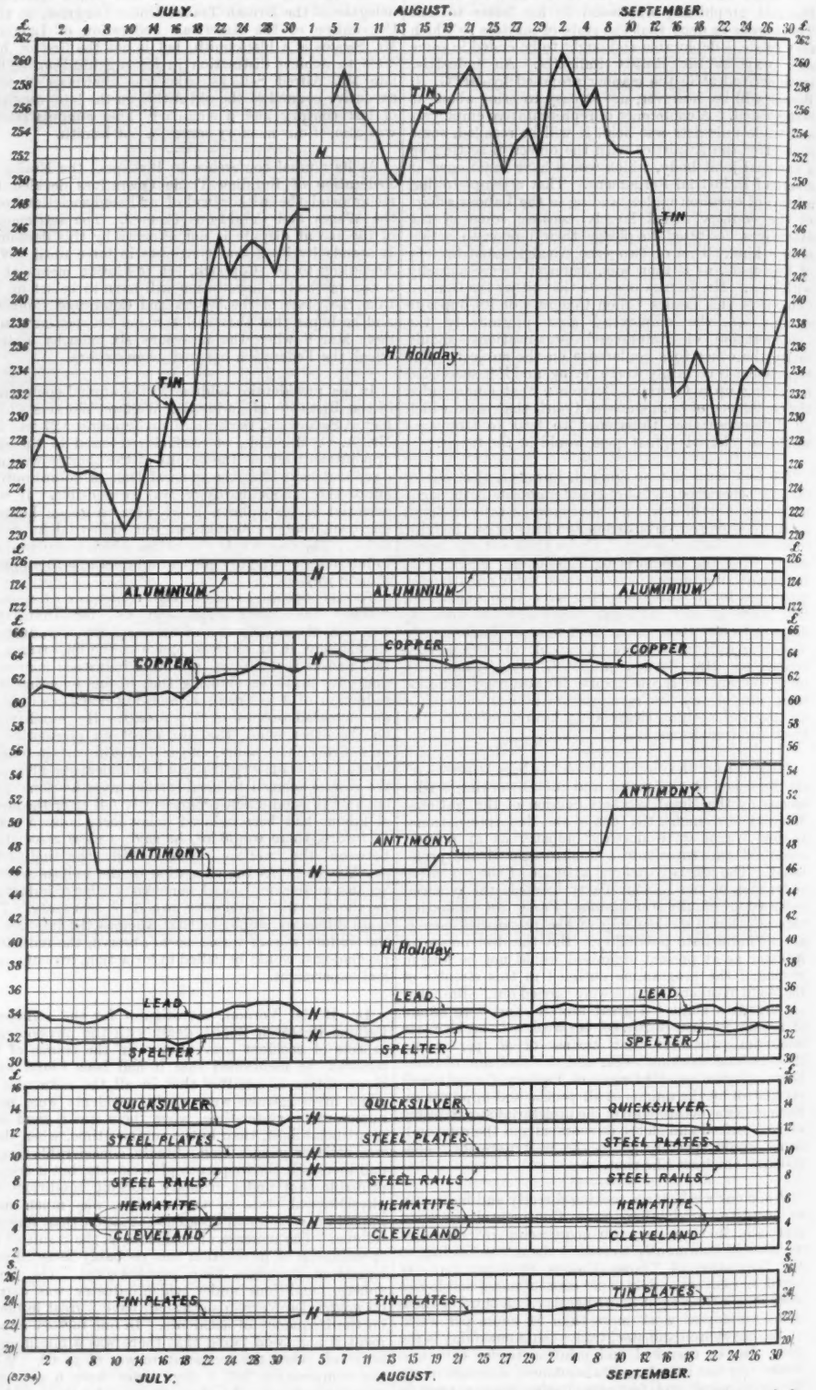
Department of Overseas Trade. Report on the Industrial and Economic Conditions in Norway, March, 1924. By C. L. Paus, C.B.E. London: His Majesty's Stationery Office. [Price 2s. net.]

Diesel Engines. Berlin: Vereines Deutsc er Ingenieure [Price 2·25 dols.]

Department of Overseas Trade. Report on the Industries and Commerce of Spain, March, 1924. By Capt. U. de B. Charles, C.B.E. London: His Majesty's Stationery Office. [Price 2s. 6d. net.]

Contracts.—Messrs. Vickers and International Combustion Engineering, Limited, have secured an order for a complete new power plant for the York-street Flax Spinning Company, Limited, Belfast. The plant will include Babcock and Wilcox boilers having 9,270 sq. ft. of heating surface each, which will be fired by pulverised coal on the "Lopulco" system. Messrs. Henry Berry and Co., Limited, hydraulic engineers, Leeds, have been awarded the contract by Messrs. Dorman, Long and Co., Limited, London, for the whole of the hydraulic machinery to be used in the construction of the Sydney Harbour Bridge.—In connection with the new underground electric railway being constructed by the General Post Office, London, we learn that Messrs. Spencer (Melksham), Limited, engineers and contractors, of Melksham, have secured the order for the whole of the conveyors and elevators to be installed at the postal stations of King Edward Buildings, Liverpool-street Station, Western District, Eastern District, West Central District, and the Mount Pleasant Parcels and Letter Post Offices.—Messrs. Bruce, Peebles and Co., Limited, engineers, Edinburgh, have secured the contract for the supply of two 7,500-kw. alternators to be used in connection with the Lake Coleridge Hydro-electric Power Station of the New Zealand Government.—We are informed that the contract for structural steelwork for Messrs. Cravens Railway Carriage and Wagon Company, Limited, Sheffield, has been secured by Messrs. Thos. W. Ward, Limited, Albion Works, Sheffield.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS.



Note.—In the diagrams the figures plotted for tin and copper are the official closing cash quotations of the London Metal Exchange for fine "foreign" and "standard" metal respectively. The prices shown for lead are for English metal, whilst those for spelter are for American metal. Middlesbrough prices are plotted for steel plates and rails, and also for hematite and Cleveland pig-iron. The prices given, in the case of steel plates are for ship, bridge and tank qualities, and those for steel rails are for heavy sections. The pig-iron prices are for East Coast hematite and Cleveland iron, both of No. 1 quality and for home consumption. The price of quicksilver is per bottle, the contents of which vary from 70 lbs. to 80 lbs. The price of tin-plates is per box of I.C. cokes f.o.b. at Welsh ports, but in all other cases the prices are per ton. Each vertical line in the diagram represents a market-day, and the horizontal lines represent 1*l.* each, except in the case of the diagram relating to tin-plates, where they represent 1*s.* each.

Personal.—Messrs. James Gordon and Company, Limited, of Windsor House, Kingsway, London, have recently opened a branch office at 110, Waterloo-street, Glasgow, under the management of Mr. A. D. Burgess.—We learn that Mr. Harry Allcock associated with the firm of Messrs. W. T. Glover and Company, Limited, has joined the Board of Messrs. Royce Limited, Trafford Park, Manchester.—Mr. F. W. Lanchester, Consulting Engineer, of 41, Bedford-square, London, W.C.1, will in future conduct business from his office at the Daimler Works, Coventry, while his private address will be Dyott End, Oxford-road, Moseley, Birmingham.

THE BASSLER LIQUID METER.

CONSTRUCTED BY THE BRITISH LIQUID METER COMPANY, LIMITED, ENGINEERS, LONDON.

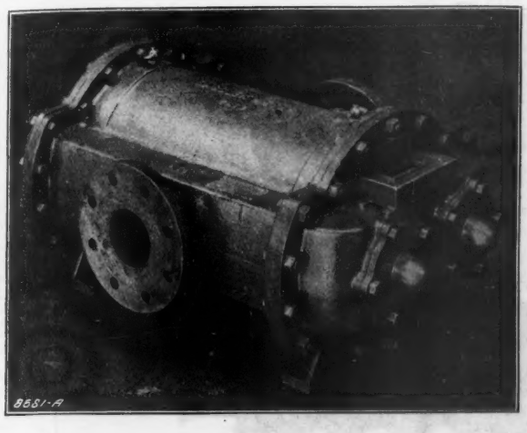
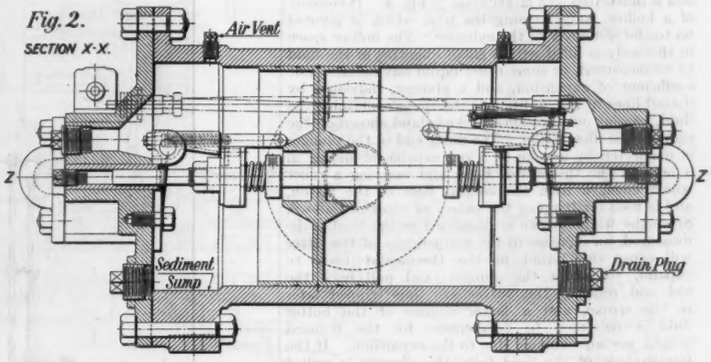
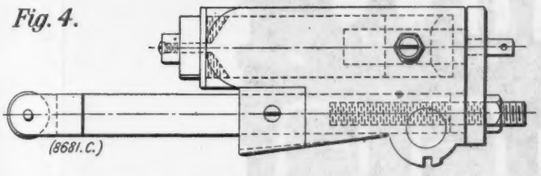
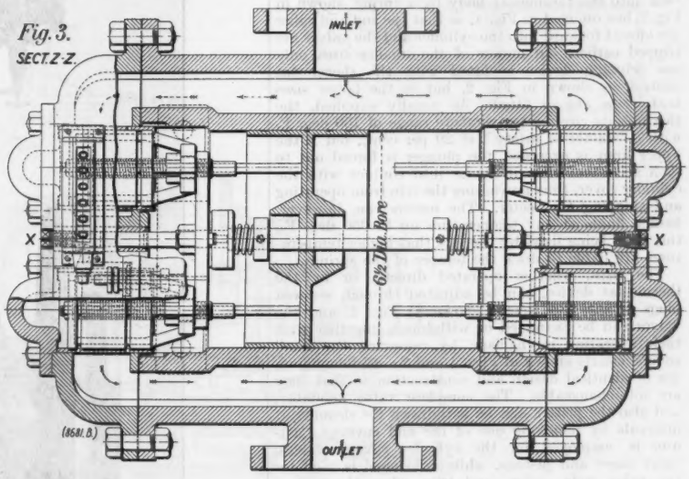


FIG. 1.







THE BASSLER LIQUID METER.

FOR many industrial purposes the measurement of the flow of liquids to within about 1 per cent. of accuracy meets all requirements, and there are many different types and designs of meters on the market which are capable of giving this, or an even higher, order of accuracy when working under uniform conditions. In most cases, however, the results are affected by variations in the temperature, viscosity and rate of flow of the liquid, or by the pulsations in the flow which occur in the delivery from reciprocating pumps, so that when measurements of high accuracy are desired it is frequently necessary to employ weighing methods or to use calibrated tanks, making allowance, with the latter, for any considerable variation in the temperature of the liquid.

The accompanying illustrations show a form of fluid meter, known as the Bassler meter, which, we understand, has been extensively employed in the United States for some two or three years, and which the makers guarantee will give measurements with an error of less than 0·1 per cent. over a temperature range of 150 deg. F., and irrespective of changes in the viscosity of the fluid or of pulsations and irregularities in the rate of flow. The Bassler meter is now being made in this country and has recently been placed upon the market by the British Liquid Meter Company, Limited, 7, Victoria-street, Westminster, S.W.1. Fig. 1 shows the external appearance of a Bassler meter with 4 in. flanged connections and having minimum and maximum capacities of 3,750 and 25,000 gallons per hour, while Figs. 2 and 3, which are a longitudinal section and a sectional plan, respectively, serve to illustrate its design and construction. Six standard sizes are now being made for pressures up to 350 lb. per square inch, and for flows ranging from 5 to 120,000 gallons per hour, although larger and smaller meters can also be supplied. These meters are particularly suitable for measuring and controlling the supply of oil to liquid-fuel burners or to internal-combustion engines; for measuring vegetable and mineral oils, petrol and other spirit oils to or from bulk storage installations, tank steamers, wagons, &c.; and for measuring the flow of cold or hot water for boiler-feed or other purposes. Their high accuracy, it is stated, also enables them to be used for checking the calibration of large tanks or tank wagons.

As will be understood on reference to Figs. 2 and 3, the meters are of the single-cylinder, positive-displacement type, each stroke of the piston delivering a definite quantity which can be accurately adjusted by means of a valve tripping device. The latter is controlled by a thermostat, which will be described in detail later, when the meter is required to measure the weight of fluid delivered irrespective of volume changes due to temperature variations, but meters are also supplied without the thermostatic control for use when the measurements are required to be by volume only. The general arrangement of the meter will be clear from the illustrations, from which it will be seen that the cylinder is formed with inlet and outlet passages on opposite sides, the passages leading to inlet and outlet valves of the piston type, working in cages fitted in the end covers. One inlet and one outlet valve is employed at each end of the cylinder, the inlet valves being uppermost in Fig. 3. As drawn in that illustration, fluid is flowing from the inlet connection through the inlet valve in the top right-hand corner and forcing the piston towards the left, while the fluid from other end of the cylinder is being forced out through the outlet valve in the bottom left-hand corner of the illustration to the outlet connection; the path of the fluid through the passages is indicated by the full-line arrows.

As the piston approaches the end of its stroke, a conical boss formed on the centre of the piston comes into contact with a roller of the valve-tripping device, as indicated on the left of Fig. 2, and, at the same time, the flat web of the piston touches the ends of the valve stems which extend into the cylinder as shown in Fig. 3. The valves are connected to the stems through helical springs, and further movement of the piston puts a tension on these springs without, at first, moving the valves. At this stage the latter are still held by the trip gear, which engages with a yoke connecting each pair of valves, as can be followed in Fig. 3. As the piston continues to move, however, the trip is released in two steps, the first step permitting the valves to close partially, and thus reduce the rate of flow of the fluid, and the second step allowing them to close completely. All four valves, it should be noticed, move together, since the yokes are connected by a rod which passes through the centre of the piston, so that as one pair of inlet and outlet valves closes, the other pair opens. The fluid then flows from the inlet in the direction of the dotted arrows in Fig. 3, and that which entered the right-hand end of the cylinder on the previous stroke is then forced out through the valve at the bottom right-hand corner of the illustration, flowing to the outlet as indicated by the dotted arrows. The control of the valve movement in two steps, as mentioned above, is an important feature of the design of the meter, and is that which prevents the accuracy from being impaired by changes in pressure, viscosity or rate of flow. The first partial closing of the valves ensures that one end of the cylinder is completely filled, and the contents of the other end are fully discharged before the valves are finally closed.

The strokes of the piston are counted, in order to record the total quantity of fluid passed, by means of a twisted square rod, which passes through a babitted sleeve in the web of the piston and is carried in ball-thrust bearings mounted in the end covers, as indicated by the chain-dotted lines in Fig. 2. At one end, the rod is provided with a double ratchet through which it is connected to integrating mechanism of the cyclometer-dial type. This is enclosed in a rectangular cast-iron box mounted on the end cover as shown in Fig. 1. No leakage, it is stated, takes place past the piston or by way of the openings in the web through which pass the counter rod and the rod connecting the valves. This follows from the fact that the pressures on the opposite sides of the piston are practically equal, the pressure difference being only that required to overcome the slight frictional resistances. No lubrication is necessary, other than that provided by the working fluid, and even when the latter is of a non-lubricating character, such as petrol, no indication of undue wear has been noticed after extended use. The trip points, it should be mentioned, are case-hardened to reduce wear, and thus to ensure accurate working over long periods. To bring the valves quietly to rest at the end of their travel, the end of each valve is spigoted so as to fit into a recess formed on the inner face of the valve cover, as can be seen near the bottom left-hand corner of Fig. 3. The recess, which is filled with fluid when the meter is in operation, thus acts as a dash-pot. Similar dash-pots for the piston are formed by recesses in the boss, into which adjustable collars on the valve rod enter at the end of each stroke. The cylinder is counterbored at each end, as shown in Fig. 2, to form a sump for sediment, which can be removed at intervals through screwed plugs. Air vents are also provided at each end of the cylinder to

enable the latter to fill with fluid when first starting up.

It now remains to explain the thermostatic device fitted to compensate for temperature changes in the fluid being measured, so that the readings indicate a definite weight of fluid irrespective of its volume. This device is shown in position on the right of Fig. 2, and is illustrated to a larger scale in Fig. 4. It consists of a hollow body forming the trip, which is pivoted on to the end cover of the cylinder. The hollow space in the body is filled with a small quantity of the fluid to be measured, or some other liquid having the same coefficient of expansion, and a plunger, indicated by dotted lines in Fig. 4, fits into the space containing the fluid, passing out through a packed gland shown on the right of the illustration. The outer end of the plunger is connected by a yoke to a rod capable of sliding in a hole in the thermostat body and carrying a roller which engages with the conical boss of the piston, and is used for tripping the valves as explained above. Since the whole device is immersed in the fluid to be measured, an increase in the temperature of the latter will cause the liquid in the thermostat body to expand, force out the plunger, and pull back the rod and roller. The valves are thus tripped later in the stroke, and a larger volume of the hotter fluid is delivered to compensate for the reduced weight per unit volume due to the expansion. If the temperature of the fluid falls, the plunger is pulled back into the thermostat body by a spring, shown in Fig. 2, but omitted in Fig. 4, so that the rod and roller are moved forward into the cylinder and the valves are tripped earlier. In meters of the smaller sizes, only one tripping device is fitted with the thermostat control, as shown in Fig. 2, but in the larger sizes both trips are so fitted. As usually supplied, the thermostats cover a temperature range of 150 deg. F. with a "factor of safety" of 20 per cent., but if the upper limit is exceeded, the plunger is forced out to such an extent that it comes into contact with the cylinder cover, thus preventing the trip from operating and stopping the meter. The meters can, however, handle fluids at any temperature up to 350 deg. F., this limit being fixed by the fact that higher temperatures are liable to draw the temper of the springs.

The trips, whether operated directly or by the thermostat device, can be adjusted through screwed plugs in the end covers, shown in Fig. 2, and the valves can be examined or withdrawn, together with their operating mechanism, by removing the small covers clearly shown in Figs. 1 and 3; all four valves are of identical design and construction so that they are interchangeable. The complete valve assembly, and also the piston, can be withdrawn for cleaning at intervals by removing one of the end covers. Cast-iron is employed for the cylinder covers, valves, valve cages and pistons, while mild steel is used for the valve rods, yokes, and trips when the meters are intended for measuring non-corrosive fluids. Phosphor-bronze liners are fitted in the cylinders of meters for measuring water, and this material is also used for the other parts which are likely to be affected by corrosive action. An automatic valve can be fitted, if required, to cut off the flow after a predetermined quantity of fluid has been delivered. As previously mentioned, the meters are suitable for measuring the oil supply to liquid-fuel burners, and they can be employed for this purpose in either land or marine installations, their action being unaffected by the motion of a ship. For this application, however, they are fitted with an automatic by-pass which maintains a supply of fuel to the burners if the meter should stop working from any cause.

FIVE-STAGE AIR-COMPRESSOR.

We illustrate on this page and opposite an air compressor, shown at the British Empire Exhibition by Messrs. Belliss and Morcom, Limited, of Birmingham. The machine has been designed for supplying high pressure air for colliery locomotives used for underground haulage. The general character of the compressor is well represented in Fig. 1, whilst the sectional drawings, on the opposite page, show details of its construction. The machine is intended to compress 353 cub. ft. of free air per minute to 2,350 lb. per sq. in., the speed of running being 210 revolutions per minute. The compression is effected in 5 stages. The air enters the compressor by the double-beat inlet valve, shown at A in Fig. 2. The opening of this valve is controlled by a relay operated by the oil pressure required for the forced lubrication with which every bearing is provided. The valves which supply or withdraw oil from below the piston attached to the inlet valve are controlled by the pressure on the discharge main. Should the demand for air fall off and the discharge pressure rise accordingly, oil under pressure is admitted below the inlet valve piston, which is thereby forced up, and closed until the pressure falls to normal.

FIVE-STAGE AIR-COMPRESSOR; EMPIRE EXHIBITION.

MESSRS. BELLISS AND MORCOM, LIMITED, ENGINEERS, BIRMINGHAM.

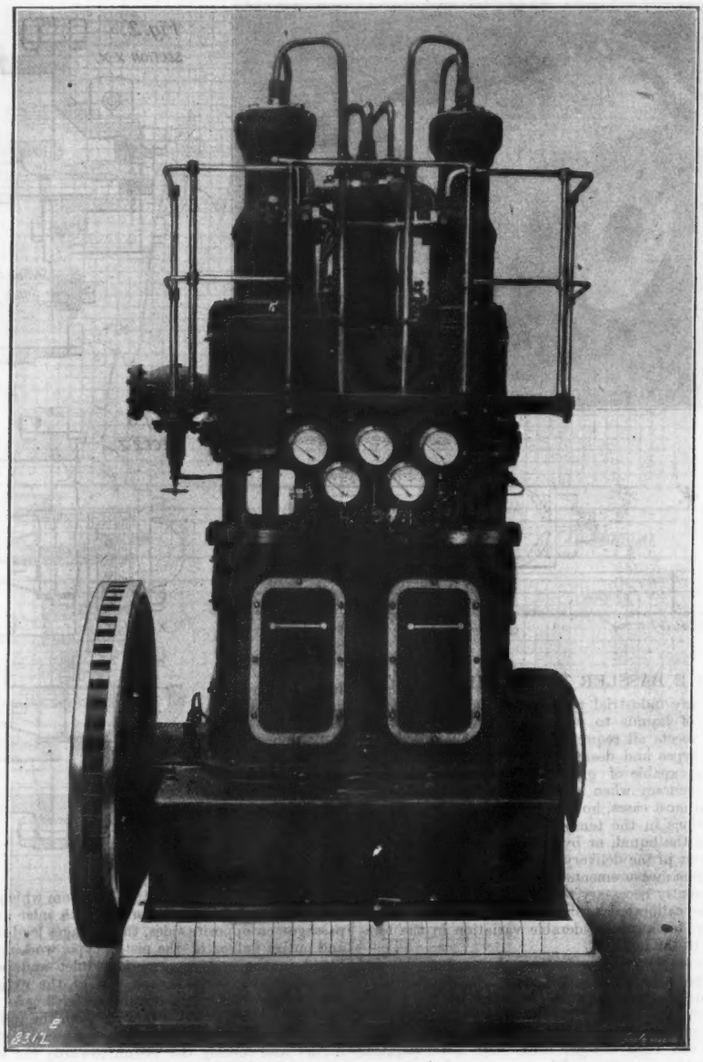


Fig. 1.

From the inlet valve the air passes to a valve box at the back of the machine, which resembles that shown at B in Fig. 4. From this box it passes either to the top or bottom of the first stage cylinder C (Fig. 2). This cylinder is, it will be seen, double-acting, and both sides of the piston belong to the first stage of compression. The air compressed in this first stage passes through the cooler D (Fig. 3) to the valve box of the cylinder E.

This is also double-acting, and in this cylinder the second stage of compression is effected. The air delivered from this cylinder is passed through a second cooler, shown at F (Figs. 2 and 3), and is then split into two portions for the third stage of compression, which is effected in the single-acting cylinders, G and H (Figs. 2, 3 and 4). These deliver the air to a third cooler, from whence it passes to the single-acting cylinder I (Fig. 2), in which the fourth stage of compression is effected. These deliver it to a cooling coil immersed in a tank from which it passes to the cylinder J, where the final stage of compression is carried out.

It will be noted that for the earlier stages of compression, the intermediate coolers are of the "surface condenser" type, the cooling water passing through the pipes indicated. For the later stages, at which the air pressure is high, the cooler consists of a helical coil immersed in a tank of water. The whole machine is very thoroughly water-jacketed throughout. Metallic packings are fitted to all glands, and the machine has proved capable of making prolonged continuous runs on full load.

University of London.—The formal opening of the Ramsay Laboratory of Chemical Engineering, instituted in 1923 as part of the memorial to the late Sir William Ramsay at University College, has now been arranged to take place in November. A full course of study in chemical engineering will be provided in this laboratory in the coming session, leading to the degrees of M.Sc. or Ph.D. Full details of courses may be had from the Secretary of University College, Gower-street, London, W.C. 1.

Paper Making Technology.—The Board of Education has issued a report on Technical Education in England on the paper-making industry. The report comprises an historical note on the art from its introduction into this country, about 1494. It is stated that the present tendency is towards larger mills and greater outputs, but expresses the opinion that costs of production can be reduced by greater scientific knowledge. The industry is one in which the value of the output per head ranks relatively high, being according to the 1907 census, 113*l.* per head, as against an average of 93*l.* per head for the nine principal manufacturing industries of the country. The report states that full time courses of instruction in the technology of the industry are provided in a number of universities and technical colleges, and that evening classes are provided in the main centres of the industry. Copies of the report can be obtained from H.M. Stationery Office, at the price of 6d. net.

FIVE-STAGE AIR-COMPRESSOR AT THE BRITISH EMPIRE EXHIBITION.

CONSTRUCTED BY MESSRS. BELLISS AND MORCOM, LIMITED, ENGINEERS, BIRMINGHAM.

(*For Description, see Opposite Page.*)

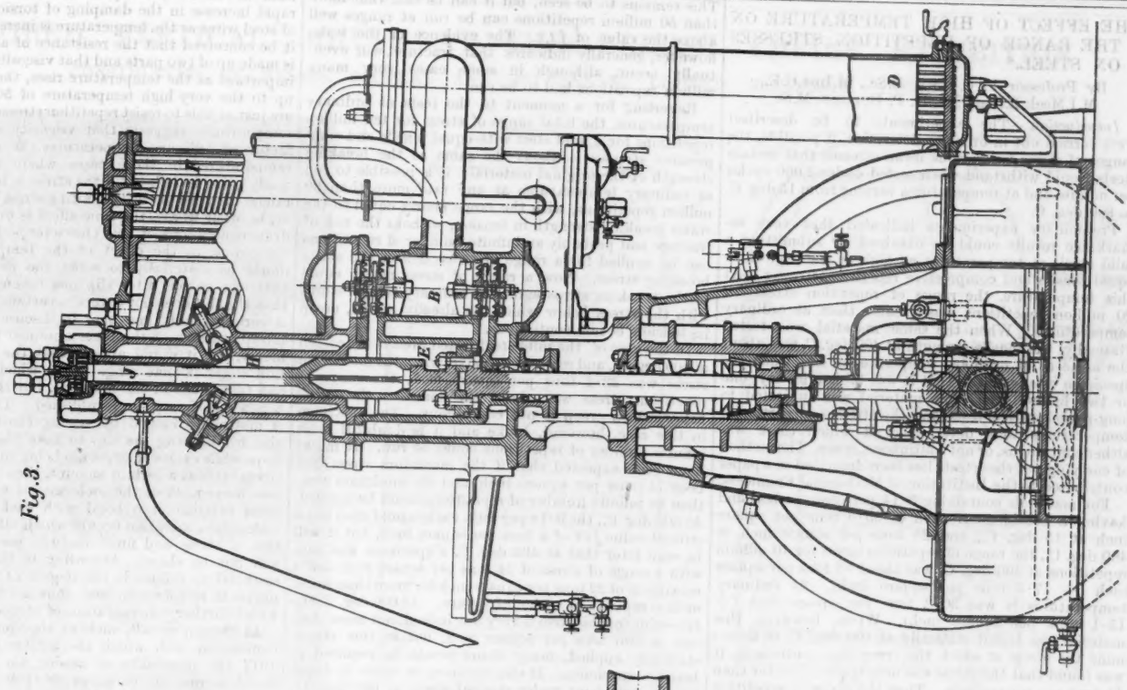


Fig. 3.

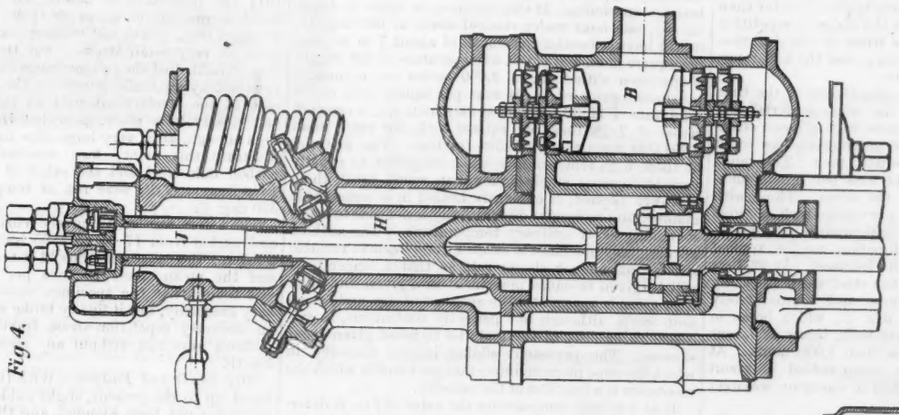


Fig. 4.

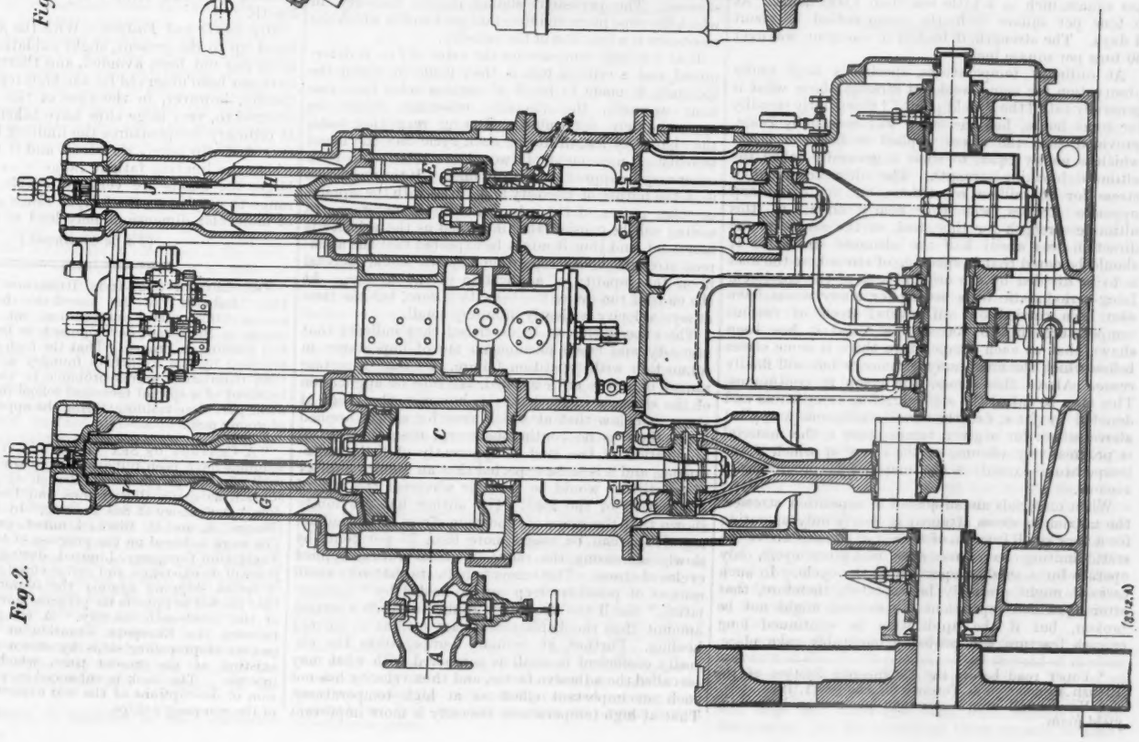


Fig. 2.

(23746)

THE EFFECT OF HIGH TEMPERATURE ON THE RANGE OF REPETITION STRESSES ON STEEL.*

By Professor F. C. Lea, D.Sc., M.Inst.C.E., M.I.Mech.E., and Mr. H. P. Budgen, M.Sc.

Introduction.—The experiments to be described were carried out in order to determine, if possible, the ranges of stress for various mean stresses that certain steels would withstand when tested under 2,000 cycles per minute and at temperatures varying from 15 deg. C. to 800 deg. C.

Preliminary experiments indicated that very remarkable results could be obtained by submitting a mild steel, at temperatures as high as 400 deg. C., to equal tensile and compressive repetition stresses. At this temperature, the range of repetition stress for 20 million repetitions was greater than at ordinary temperatures. When the same material was tested statically, the tensile strength at 400 deg. C. was about the same as at ordinary temperatures, *i.e.*, when the specimen was tested so that it was broken in, say, one or two hours. The same material was subjected to long-period statical tests, and the stresses at particular temperatures were determined at which there was either continuous, or not continuous, creep. The method of carrying out these tests has been described in a paper contributed to the Institution of Mechanical Engineers.

For materials containing 0·14 per cent. carbon and having a breaking strength of 30·6 tons per square inch at 15 deg. C., and 28 tons per square inch at 400 deg. C., the range of repetition stress for 10 million repetitions at 400 deg. C. was about 35 tons per square inch (+ 17·5 tons per square inch). At ordinary temperatures it was 30·2 tons per square inch (+ 15·1 tons per square inch). When, however, this material was tested statically at 400 deg. C. to determine the stress at which the creep was continuous, it was found that the stress was only slightly greater than 14 tons per square inch. Thus the range of repetition stress was far greater than the stress in one direction that would cause continuous creep, and the half-range stress in tension was also greater.

This illustrated at once the importance of the time effect on materials. Taking the same material and subjecting it to repetition stresses with a mean stress of 15 tons per square inch, the maximum stress could be increased to 22 tons per square inch. The range was thus a tensile stress of 14 tons per square inch, *i.e.*, there was no reversal of the stress. Thus, with a maximum stress of 22 tons per square inch, a range of stress equal to that which will produce continuous creep when applied in one direction can be applied many millions of times without fracture. At 22 tons per square inch, the creep of the steel when statically tested is apparently continuous and comparatively rapid. Another steel at 500 deg. C., which broke in 10 hours at 22 tons per square inch, broke at 7 tons per square inch in a little less than 1,000 hours. At 6 tons per square inch, the creep ceased in about 3 days. The strength, if broken in one hour, was over 30 tons per square inch.

At ordinary temperatures, specimens kept under observation for many weeks at stresses above what is generally called the "yield point,"† creep fairly steadily for some hours, but the creep will eventually cease, provided that the stress applied is below a stress which is nearly equal to what is generally called the ultimate breaking strength. The ultimate range of stress for 20 million repetitions, and for equal and opposite stresses, was very nearly equal to this ultimate strength for this steel, or the range in one direction was about half the ultimate strength. It should be noted that in speaking of stress here the load is to be divided by the original area of the specimen. Long-period static tests lasting for many weeks have also been carried out on several steels at various temperatures up to 700 deg. C., and it has been shown that at each temperature there is some stress below which the creep may commence but will finally cease. Above this stress, the creep is continuous. This may be called the static limiting creep stress and denoted by $f\,t\,v$, *i.e.*, the stress continuously applied above which for a given temperature t, the material is progressively viscous, or the stress at which if the temperature exceeds t the material is progressively viscous.

When materials are subjected to repetition stresses, the maximum stress attained is clearly only operating for a very small fraction of time, and stresses above the static-limiting-creep-stress may, in a given cycle, only operate for a small proportion of the cycle. In such cases it might probably be expected, therefore, that after 10 million repetitions a specimen might not be broken, but if the application be continued long enough fracture will probably inevitably take place. This remains to be seen, but it can be said that more than 50 million repetitions can be run at ranges well above the value of $f\,t\,v$. The evidence of the tests, however, generally indicates that fracture will eventually occur, although in some cases very many million repetitions had to be run.

Reverting for a moment to the tests at ordinary temperatures, the total range of stress for ten million repetitions for a mild steel with equal tensile and compressive stresses is about the same as the breaking strength of the original material; it is possible to run at ordinary temperatures at any rate more than 30 million repetitions, with the range nearly equal to the static breaking strength in tension, without the risk of fracture and probably an infinite number of repetitions can be applied for a range of stress 0·9 of the static breaking stress. Now a range of stress nearly equal to the breaking stress agrees at ordinary temperatures with the stress below which, as already stated, creep in tension is not continuous.

In the case of the mild steel tested always in tension at 400 deg. C., and referred to above, when the maximum stress was 22·2 tons per square inch, the range of repetition stress was about the same as the stress below which creep is not continuous. The specimen in this case, however, broke and it is doubtful if an infinite number of repetitions could be run. It might have been expected that if the maximum stress had been 14 tons per square inch, and the minimum zero, then an infinite number of repetitions could be applied. At 500 deg. C., the 0·14 per cent. carbon mild steel has a critical value $f\,t\,v$ of 4 tons per square inch, but it will be seen later that at 496 deg. C. a specimen was run, with a range of stress of 14 tons per square inch and a maximum of 22 tons per square inch for more than seven million repetitions without fracture. At 600 deg. C. the $f\,t\,v$ value for this steel is very low indeed, not more than one or two tons per square inch, but at this stress, statically applied, many hours would be required to break a specimen. If the specimen is made to break in, say, one hour under statical stress at 600 deg. C., it will have a breaking strength of about 7 to 10 tons per square inch, and yet at a temperature of 636 deg. C. a specimen withstood, at 2,000 cycles per minute, a maximum stress of 18·64 tons per square inch and a minimum of 11·36 tons per square inch, *i.e.*, a range of stress of 7·28 tons per square inch, for more than 8,291,000 repetitions without fracture. The material at these high temperatures when subjected to rapidly variable stresses much higher than would break them if slowly applied, is evidently healed in a remarkable manner, and molecular discontinuity is not able to occur so readily as at ordinary temperatures. The authors are designing machines to subject these steels to variable stresses at a much slower rate so that a longer time will be given to cause movement in a given direction. Now creep is apparently the evidence of slip, and persistent creep, although not perfectly continuous, is evidence of inability of the material to resist given shear stresses. The persistent sliding implies viscosity, in which the time plays an important part and in which the resistance is a function of the velocity.

If at a certain temperature the value of $f\,t\,v$ is determined and a critical test is then made in which the specimen is made to break at various rates from one hour upwards, the viscosity resistance might be approximately determined. During repetition tests, the change of length during each cycle and the mean velocity of movement of two planes relative to each other may be approximately obtained. If the resistance is of the nature of viscosity and varies with the square, or other power, of the velocity, then the resistance to sliding will be considerably increased as the velocity is increased, and thus it might be expected that the apparent strength under repetition stresses would depend upon the rapidity of application of the stresses. At the ends of the cycles the velocity is zero, but the time at zero velocity is clearly infinitely small.

The experiments to be described thus indicate that viscosity and creep phenomena are of importance in connection with repetition failure, and that, if certain ranges of stress are exceeded, the rate of application of the stress is important. If, however, the range of stress is below that at which even for slowly applied loads there is no continuous creep, then the rate of application of the load is apparently of little consequence, and it is to be expected that an infinite number of repetitions would be possible whatever the rate of application of the load. The author has previously shown that the range of repetition stress for 40 million repetitions can be raised more than 25 per cent. by slowly increasing the range of stress during applied cycles of stress. This seems to indicate that very small centres of possible creep can be healed by "manipulation," but if the stress first applied exceeds a certain amount then the displacements are such as to prevent healing. Further, at ordinary temperatures the viscosity coefficient is small as compared with what may be called the adhesive factor, and thus velocity has not such an important effect as at high temperatures. That at high temperatures viscosity is more important than at ordinary temperatures is indicated by the rapid increase in the damping of torsional oscillations of steel wires as the temperature is increased. If, then, it be conceived that the resistance of a metal to stress is made up of two parts and that viscosity becomes more important as the temperature rises, then the fact that up to the very high temperature of 500 deg. C. steels are just as able to resist repetition stresses as at ordinary temperatures suggests that viscosity is an important factor at ordinary temperatures, as well as at high temperatures in those cases where the material is really going to fail, but if the stress is below the fatigue range, then the viscosity limiting stress is not exceeded, or, in other words, the time effect is unimportant. To draw conclusions of this character is, however, a little dangerous, as the effect of the temperature will no doubt be materially to assist the process of healing that can go on after slip has taken place, provided that the slip does not exceed a certain amount. There is certainly not time here to discuss all the possible interpretations of the facts obtained from the experiments, but it would appear that the range of repetition stress is that range below which molecular slips can take place in the material, but that after the slip a new bond may be established. This new bonding is materially helped by raising the temperature and also by allowing the slip to take place in very small steps while cycles of stress are being run. If the applied stress exceeds a certain amount, then the degree of relative movement of the molecules is too great to allow them to come into bond with each other, and thus molecular separation occurs which allows of concentration of stress and final fracture, probably by tension and not by shear. According to this view, the first essential to failure is the degree of slip strain which prevents re-cohesion, and thus a crack is formed at which further concentration of stress may occur.

In certain metals, such as the aluminium alloys (in connection with which the author first suggested in 1917 the possibility of raising the fatigue limit by slight increments of stress as cycles were being run) wrought iron, nickel and copper, small slips can take place at very small stresses, but these heal. In the case of mild steel the fatigue range can be increased 25 per cent. by gradually increasing the stress, and in the case of the steels dealt with in this paper, healing can clearly take place, provided the temperature is high enough, after very large slips have occurred. To illustrate this point, two specimens, one of 0·14 carbon mild steel and the other of a nickel-chrome-vanadium steel S_2, were run at temperatures of about 450 deg. C.

The stress was continuously tensile in the first case and varied from 17·05 to 2·95 tons per square inch tension; the range was thus 14·1 tons per square inch and the mean stress 10 tons per square inch. It was found that the specimen continued to elongate very gradually, but it finally broke with a fracture like an ordinary repetition-stress fracture. Very many millions were run without any measurable change in length.

Slip bands and Failure.—With the apparatus developed up to the present, slight oxidation of the specimens has not been avoided, and therefore slip bands have not been observed for the high-temperature tests. Clearly, however, in the case of the specimens just referred to, very large slips have taken place. When at ordinary temperatures the limiting fatigue range is exceeded slip bands do occur, and if the amount by which the limiting fatigue range is exceeded is fairly large, the bands are very noticeable, but when the range is very near, the fatigue range slips apparently of molecular dimensions may lead to non-readhesion.

(To be continued.)

* Paper read before the Engineering Section of the British Association at Toronto on August 11, 1924.

† Very small creeps can take place even below the yield point.

The British Cast-Iron Research Association.—The "Bulletin" of this association for July contains, among other useful information, an interesting discourse on the recent developments in foundry education and training in France. That the high standard already attained by the French in foundry work will be more than maintained seems probable in view of the establishment of a special technical school in Paris to supplement part-time training during the apprenticeship period of young men.

"A Century of Sea Trading."—Though numerous volumes have been published from time to time dealing with the development of British shipping, few works contain so many illustrations and historical details as does "A Century of Sea Trading," by L. Cope Cornford (Messrs. A. and C. Black, Limited, price 10*s.* 6*d.* net). The work is based on the progress of the General Steam Navigation Company, Limited, during the first hundred years of its existence, and in it is clearly traced the growth of steam shipping against the innumerable handicaps that tended to impede its progress during the early part of the nineteenth century. A comparison is drawn between the European situation at the start of the project of propelling ships by steam in 1824, and that existing at the present time, which possesses much interest. The book is enhanced in value by the inclusion of descriptions of the war experiences of a number of the company's ships.

OIL-FIRED VERTICAL BOILER AT THE BRITISH EMPIRE EXHIBITION.

CONSTRUCTED BY MESSRS. COCHRAN AND CO. (ANNAN), LIMITED, ENGINEERS, ANNAN.

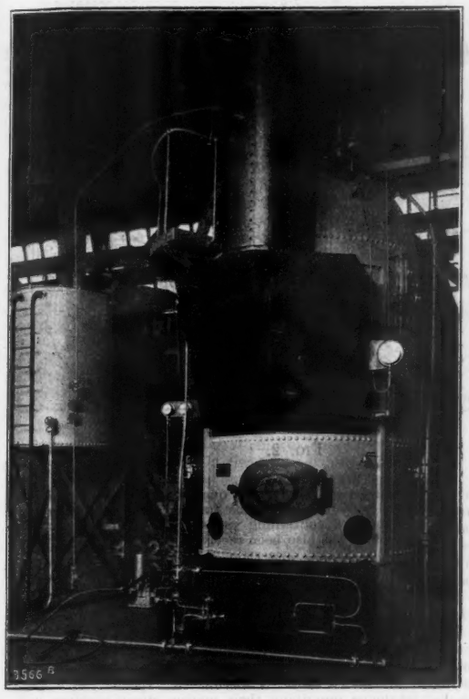


FIG. 1.

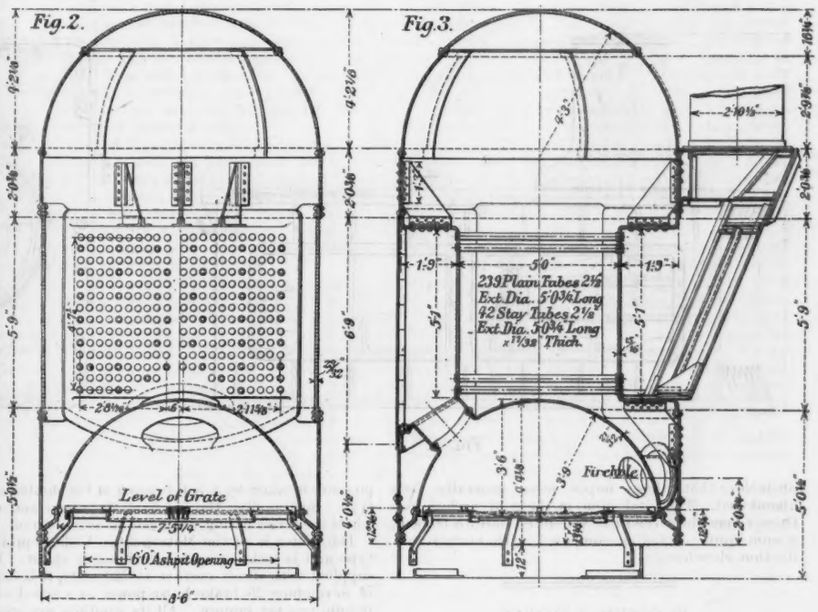
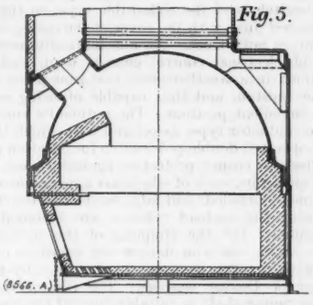
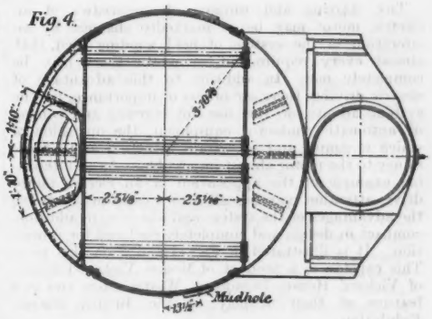


Fig. 2.
Fig. 3.
239 Plain Tubes 2½" Ext. Dia. 5'0¾" Long
42 Stay Tubes 2½" Ext. Dia. 5'0¾" Long x 11/32" Thick.
Level of Grate
6" Ashpit Opening
Firehole





OIL-FIRED COCHRAN BOILER.

FOR purposes of generating steam in quantity, sufficient to meet the requirements of power plants of small works, the vertical boiler has many distinct advantages, such as the use of very little floor space, while their self-contained construction makes unnecessary the building up of a brickwork setting. As this type of boiler is manufactured in standard sizes, economy in production costs has been obtained and the prices are in consequence comparatively small. A good example of the type is the well-known Cochran boiler made by Cochran and Co. (Annan), Limited, Annan, Scotland. An illustration of a complete boiler of this make, which is fitted with oil-firing equipment as shown on Fig. 1, while the details of the standard coal-fired boiler and the modifications introduced for purposes of burning oil fuel are shown in Figs. 2 to 5.

The Cochran boiler has a furnace dome which is pressed from a single plate and is, therefore, free from the troubles that would be experienced were riveted seams exposed to the flames. From the furnace the gases enter a combustion chamber at the back, from which they are conducted through a bank of parallel horizontal tubes of 2¼-in. external diameter, to the smoke box in front. The 22 standard sizes in which these boilers are made range from a diameter of 3 ft. and height of 6 ft. 9 in., giving an evaporation of 360 lbs. per hour, up to a diameter of 8 ft. 6 in., and height of 17 ft., which can give 6,600 lb. per hour. It is the largest size of which the details are shown in Figs. 2, 3 and 4. The construction of the Cochran boiler is such that internal accessibility for cleaning and inspection is an outstanding characteristic. Through the manhole fitted in the hemispherical top every part of the internal structure may be readily reached. The top row of tubes forms a convenient platform for the examination of the wall of the dome-shaped steam space and from the same position the vertical spaces between the tubes may be used for scaling purposes. Between the shell and the nest of tubes ample space is available for a man to get down at each side, and thus the horizontal rows of tubes may be examined and the scale visible from that position may be removed. In boilers of 4 ft. diameter and upwards it is possible to enter the firebox through the furnace opening, and the combustion chamber can be reached through the uptake, for the examination and expansion of the tube ends.

These boilers have, in addition to their extended use ashore with coal firing, been adopted to the burning of oil fuel for installation in motor ships for the driving of auxiliaries and also for land service. For this purpose enlargement of the furnace volume is required and Fig. 5 indicates clearly how this is effected. It will be noted that the grate and its supporting system are removed and that the boiler is erected upon a cylindrical base, made up from plates, which are lined internally with fire brick. Ample protection is thereby afforded for the riveted seams at the junction of the furnace dome and the ring, as well as at the junction of the extension provided to obtain a larger volume for the combustion of the oil. A firebrick arch is erected over the oil burner to direct the path of the flames in their passage to the tubes. It will be appreciated from Fig. 5, that the increased volume which is necessary to burn oil fuel, as compared with coal, has been obtained in an exceedingly simple and cheap way, and without any alteration of the essential features of the construction of the boiler. Already many boilers of the size illustrated have been installed for the provision of steam for auxiliary purposes on motor ships.

STEEL OIL-DRILLING BITS.—The United States Department of the Interior has recently undertaken to study the efficiency of drill bits and steel parts used in the boring of oil wells. A metallurgist attached to the Petroleum Experiment Station of the U.S. Bureau of Mines, Bartlesville, Oklahoma, has been appointed to conduct the investigation. The time lost due to wear and breakage of steel components is also to be considered. Figures obtained by the U.S. Bureau of Mines from a lost-time investigation of oil-well drilling show that in rotary boring only 31·2 per cent. to 36·5 per cent. of the time necessary to complete the work is spent in actual drilling, 21·5 per cent. to 29·3 per cent. of the time being taken up with pulling out and running in to change bits. It is intended to widen the present field of experiments later.

COPPER ORE IN FINLAND.

SOME interesting news comes *vid* Helsingfors from the Northern News Service that the huge copper ore field at Outokumper, East Finland, discovered in 1909, but never properly worked, is about to be exploited. The site of the deposit is situated some 10 miles from Lake Saima, which is connected with the sea by a canal. The stratum of copper-bearing ore is about 1 mile long, and has a width of from 7 ft. to 28 ft., the depth being unknown, however, beyond the fact that 600 ft. down there is no difference in the width or character of the ore, which embraces iron, copper, pyrites and zinc. The copper content is from 4 per cent. to 5 per cent., and that of the zinc 1·5 per cent.

The field, so far as has been ascertained, is calculated to hold 300,000 tons of copper, to the value of, roughly, 20,000,000*l.*

During the Great War, when no sulphur could be imported, the latter was extracted from the field, and used for pulp and paper manufacture. At Outokumper an experimental plant has been at work securing copper since 1914, and the results show that a proper exploitation, even with the present low price of copper of 63*l.* per ton, would yield a considerable profit. The mine is now being thoroughly organised, and considerable development is anticipated. The great deposit, half of which is owned by the State and the other half by the firm of Flackman and Co., is considered in Finland to be a valuable acquisition to the country.

There has been talk of reviving the river gold-mining industry in the North of Finland by the aid of modern machinery, but this is largely speculative. The gravel of many of the northern rivers is no doubt auriferous, and hope has often run high with regard to new discoveries, but the conditions there present so many

ELECTRIC CAPSTAN AT THE BRITISH EMPIRE EXHIBITION.

CONSTRUCTED BY MESSRS. VICKERS LIMITED, ENGINEERS, LONDON.

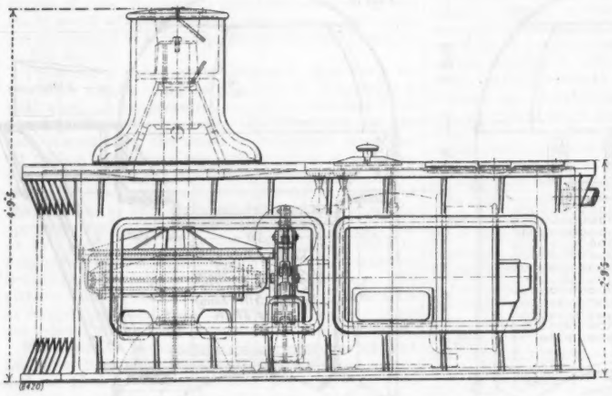


Fig. 1.

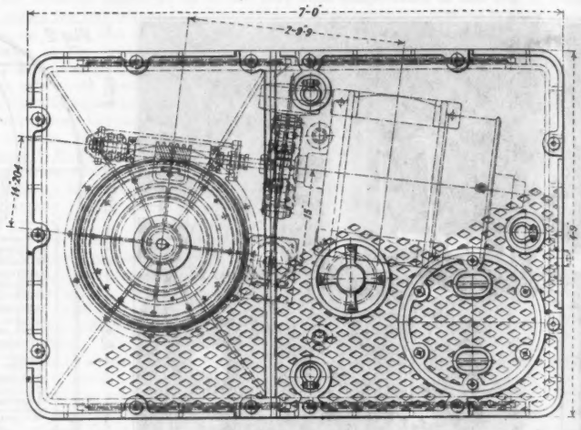


Fig. 2.

obstacles that these hopes have generally been abandoned. The total value of the gold washed from these rivers since 1895 has amounted only to 60,000*l.*, a sum quite negligible compared with modern production elsewhere.

ELECTRIC CAPSTAN.

The starting and running characteristics of an electric motor may be so markedly changed by an alteration in the system of field winding used, that almost every requirement of power users may be completely met. In addition to this advantage of electric driving there are others of importance, for the system admits of the use for starting and control of automatic contactor equipment, the operation of which is simple and so certain in action as to make injury to the motor almost impossible. As an interesting example of the application of an electric-motor drive, attention may be called to a capstan possessing the advantages of the system and which is, in addition, compact in design and completely enclosed for protection. It is illustrated in Figs. 1 and 2 on this page. This capstan is a product of Messrs. Vickers Limited, of Vickers' House, Broadway, Westminster, and is a feature of their display at the British Empire Exhibition.

The capstan is of the box type and was designed for use in railway goods yards and colliery sidings, as well as for ordinary haulage purposes. It is capable of exerting pulls up to 1½ tons at a rope speed of 130 ft. per minute as a normal duty. To obtain a suitable speed for the bollard, a worm drive is introduced, to the worm shaft of which the motor is directly connected by means of a flexible coupling. Starting and stopping are effected by the use of a pedal switch on the box, conveniently situated for the operator's control. To start the motor the pedal must be depressed, and to keep it running continued pressure is necessary, as it is so arranged that the moment the pedal is released the electric circuit is interrupted and a brake is brought into operation. When the pedal is again forced down the brake is released by the action of a solenoid.

The compactness of the design may be clearly seen from the illustrations, and as the details have been well thought out the capstan has much to recommend its extended application. The casing is made as a single-piece casting, which is strongly ribbed and is watertight. For the purpose of draining off any moisture, the bottom of the box is made continuously sloping towards one end, from which the moisture can be removed should it be necessary. This casing is designed to be firmly embedded into a concrete foundation without the use of holding-down bolts. For the cover two ribbed plates are used, the one over the motor being provided with lifting rings and also with an inspection door which is readily removable. The bollard, which is made of close-grained cast-iron, is securely keyed to a vertical shaft which carries the worm wheel. The worm wheel is constructed of a cast-iron hub keyed to the main shaft and a rim of bronze in which the teeth are machine-cut. Substantial bearings with gun-metal bushes carry the rolled-steel main shaft. The worm is made of forged steel in one piece with its shaft, which is carried on self-aligning ball bearings of the radial type, while axial pressure is taken by a ball bearing of the double-thrust type. Surrounding the whole of the worm and worm wheel there is a casing arranged to act as an oil bath.

The motor is of the Metropolitan-Vickers protected type and is series wound with limiting shunt. When supplied with direct current at 220 volts, it is capable of developing 25 brake horse-power at a speed of 960 revolutions per minute. All its windings are specially impregnated to prevent damage by moisture. The pedal switch is of the collapsible type, so that it can be dropped flush with the cover of the casing when the capstan is not in use. An automatically accelerating type of electrical control gear is used, and this is contained in a weather-proof cast-iron pillar external to the capstan, and thus capable of being set up in any convenient position. The automatic controller is of the contactor type, associated with which there is a hand-operated double-pole switch for isolation purposes and fuses to ensure protection against excess current. The contactors, each of which has a magnetic blow-out, are time controlled, and adjustable time overload and instantaneous no-load releases are included in the equipment. For the coupling of the motor to the worm shaft, cast-iron flanges are keyed to each, and the drive is taken from one to the other by means of leather or Dexine washers. The rim of the flange on the motor shaft is suitably formed for use, as the brake drum and cast-iron shoes fitted with Ferodo pads form the necessary friction surfaces. The brake is of the post type, and the shoes are held in engagement by a steel lever, to one end of which a weight is attached, release being effected by the use of a magnetic solenoid acting on the other end of the lever. When the pedal switch is depressed the solenoid is energised, thus overcoming the effect of the weight.

CATALOGUES.

Water-Turbine Governor.—A new catalogue of the Seewer governor for hydraulic turbines of the impulse type has been issued by the English Electric Co., Limited, Queen's House, Kingsway, London, W.C.

Marine Telephones.—The marine "laryngaphone" is a telephone specially constructed for use in situations on ships and elsewhere where excessive noise would render the ordinary telephone unreliable or quite useless. A catalogue describing the apparatus has come to hand from the Telephone Manufacturing Company, Limited, West Dulwich, London, S.E. 21.

Fuel Economisers.—Messrs. E. Green and Son, Limited, Wakefield, have sent us a copy of a new edition of their catalogue of fuel economisers for steam generating plant, containing full descriptions of the various types constructed and of the methods of installation. In addition, much technical and practical information is given which will be useful to engineers in charge of steam plant.

Railway Breakdown Cranes.—A catalogue received from Messrs. Thomas Smith and Sons (Rodley) Limited, Rodley, near Leeds, contains illustrations of a number of steam-driven breakdown cranes capable of lifting from 5 to 25 tons, and of a hand-operated crane for lifting 12 tons. These cranes, which are of various types, have all been supplied by the firm to railway companies in this country or abroad.

Pyrometer.—Messrs. Siemens Brothers and Co., Limited, Woolwich, have issued a new catalogue of the Siemens calorimeter-type pyrometer which enables high temperatures to be measured by noting the temperature rise in a known quantity of water in which a small body heated in the furnace has been immersed. A pamphlet containing views of the Woolwich works and plant has also been received.

Motor Starters and Controllers.—A catalogue received from the British Thomson-Houston Company, Limited, Rugby, deals with direct-current reversing-drum controllers for shunt, series and compound wound motors, resistances, limit switches, &c. Another catalogue from the same firm gives prices of combined starters, controllers and resistances for direct-current motors, including slow-running and dynamic-braking types.

Marine Geared Turbines.—A special eight-page catalogue describing their marine steam turbines with reduction gearing, has been issued by the Metropolitan-Vickers Electrical Co., Limited, Trafford-park, Manchester. Amongst the ships fitted with these turbines are the French twin-screw steamer Cuba, of 9,000 s.h.p., the Brocklebank liner Mangalore of 5,000 s.h.p., and the British Tanker Company's oil tanker British Grenadier, of 2,750 s.h.p.

Electrical Apparatus.—The General Electric Company, of New York, U.S.A., have issued a pamphlet containing illustrations of their works at Schenectady and elsewhere, which gives a good impression of the large scale organisation of production and the great variety of products turned out by the concern. The most striking features are the progress made in the size and capacity of machine tools and the extending employment of women and girls in light mechanical work.

Electro-Medical Apparatus.—Several catalogues of electrical instruments and apparatus used for curative purposes are to hand from Messrs. Watson and Sons Limited, Parker-street, Kingsway, London, W.C. One of these is a large octavo list of general electro-medical equipment; another deals with the application of X-rays to dental work; and a third relates to an intensifier screen for radiography. The catalogues are of special interest to members of the medical and allied professions.

Machine Tools.—A catalogue received from Messrs. A. A. Jones and Shipman, Limited, Leicester, illustrates a very wide range of vertical drilling machines, several radial drilling machines, a small tapping machine, a horizontal centring machine, a number of twist-drill grinding machines, and a variety of universal, cutter, tool, cylindrical, internal and surface-grinding machines. Many useful machine-tool accessories, such as steadies, tables, dividing heads, vices, &c., are also dealt with in the catalogue, which is a very creditable production.

Pottery.—An attractive book, giving a brief historical account of the Royal Doulton Potteries at Lambeth, Dudley, St. Helens, Burslem and Paisley, recently to hand, is of unusual interest owing to the wide range of arts and industries in which pottery is employed. Domestic and artistic ware, statuary, water and sewage pipes, sanitary fittings, crucibles, electrical insulators, and building stone-ware are all illustrated in the book, which is a highly creditable production in all respects. It has been issued by Messrs. Doulton and Co., Limited, Lambeth, London, S.E.

Oil Engines.—The catalogue of small oil engines recently issued by Messrs. Petters, Limited, Yeovil, is one of the most complete and best-arranged of its kind. The engines listed range from 5 b.h.p. to 36 b.h.p., with maximum powers of about one-sixth more, and there are also three small engines, for which there is a considerable market, developing 1½, 3 and 5 b.h.p., respectively. The engines are made in fixed, portable and marine types, and are started from cold by inserting a patented cartridge in the vaporiser in order to generate the necessary heat. In addition to separate engines, there are shown sets in which the engines are coupled to electric generators, pumps, air compressors, hoists, mortar mills, concrete mixers, &c.

OUTSTANDING FEATURES OF SWEDISH PRACTICE IN STEAM POWER PRODUCTION.*

By HOLGER A. LUNDBERG, C.I., Secretary to the Fuel Research Board, Ingeniörsvetenskapsakademien, Stockholm.

STEAM power in Sweden is mostly used for traction purposes and only in a smaller degree for the driving of mills. In stationary steam power plants, the co-operation on the one hand with the hydro-electric plant and on the other hand with the steam plant of the mill for heating purposes, has created interesting types of plants and arrangements, typical of Swedish practice.

The development of the Swedish locomotives has run parallel with the development in other countries. Among newer constructions in this field should be mentioned the corrugated, spiral shaped boiler tube, improving the heat transmission from the flue gases to the water of the boiler. Thus a better economy is possible for the same length of boiler. Its disadvantages are increased resistance to the flow of the flue gases, which must be overcome by a more rational arrangement of the blower, as well as a somewhat, increased difficulty in removing the soot deposits, which however, is of less importance.

As long ago as December, 1923, trials in regular traffic on the State railways were carried out with a condensing steam turbine locomotive of the Ljungström type. [See ENGINEERING, vol. cxiv, pages 64, 131, 163, 198.]

As a marine engine, also, the steam turbine is forging ahead. There are two main firms, A. B. de Lavals Angturbin, Stockholm, and Svenska Turbin-fabriks, A.B. Ljungström, Finspong, who build turbines of Swedish design.

Air pre-heating in marine service as well as in stationary plants is also progressing. The advantage of this measure is that the air pre-heater takes the place of the economiser on board, where the latter cannot be used, and in heat-consuming industries, where hot condensate is used as feed water. In Sweden the Ljungström air pre-heater is the most common. It can be defined as a rotary heat regenerator, in which the heat accumulating mass revolves very slowly and conveys the heat from the flue gases to the air on its way to the furnace.

Such stationary steam power plants, which do not produce steam for heating purposes, or at any rate do not do so on a large scale, and where no waste wood is available, are one by one being shut down and replaced by water power from the electric transmission systems. The sawmills, burning their own refuse, continue to do so. Industries consuming heating steam, such as paper mills and cellulose mills, extend their back-pressure plants and produce cheap steam power in combination with the heat distribution. The electric power undertakings increase primarily their water power stations but also simultaneously their auxiliary steam power plants. It is typical of the development, that the steam turbine is very rapidly superseding the reciprocating engine. In 1913 turbines represented 27 per cent. of the total installed steam power, they increased to 36·5 per cent. in 1917 and reached 52 per cent. in 1921. Modern plants, as built to-day, are generally fairly large and almost always interlinked electrically.

The total amount of steam power installed in the plants of miscellaneous industries, usually small, was 104,000 h.p. in 1921. Many of these plants, perhaps half of them, were not working. But some of them, such as the power plants of brickyards and dairies with an aggregate power of 20,000 h.p. are certainly used. These plants are numerous and very small, and in consequence the electric transmission lines can scarcely reach them. Dairies use steam for heating purposes. A dairy cannot dispense with the boiler and its attendant apparatus by the introduction of electric power. However, an investigation has just now been started to ascertain if the whole demand of energy of the dairies for motive power, as well as for heating, could not be supplied by electricity. Such a combination is perhaps practicable because of the possibilities for accumulating steam during the night and using it in the daytime. With this arrangement the cost of power can be kept quite low. The general trend of development is that such small steam power plants are shut down as soon as they can be reached by the spreading branches of electric transmission lines.

No less than 20 to 25 per cent. of the available steam horse-power is installed in sawmills, which use their waste wood, especially sawdust, as fuel. Sawdust as a fuel is rather troublesome, because of its moisture and its very low calorific value per unit of volume, 450,000 cal. per cubic metre or 50,000 B.Th.U. per cubic foot, being a common figure. This is the reason why it cannot be stored or transported, but must be burnt practically at the rate it is produced at the mills.

However, water forces its way even into this industry. If a sawmill is allied with some other steam-consuming industry, the sawdust is used to produce steam for heating purposes in the latter. Such a combination is formed, if the sawmill is supplemented by a cellulose mill. The sulphate cellulose mills especially use waste wood from the sawmills, and from the forests as raw material. In such cases all sawdust and also the larger refuse of very poor quality is generally burnt in the boilers of the cellulose mill to raise the steam needed for heating purposes. This steam is first led through a back-pressure turbine to produce power, before it is utilised in the digesting and drying plants. For additional power water power is used.

The introduction of thin saw-blades and other improvements in sawing methods have done much to reduce the waste. If there are other industries in the neighbourhood of a sawmill, especially sulphate pulp mills, these will be consumers of the larger refuse. In such cases the difficulty is not how to get rid of the sawdust, but how to make both ends meet, in other words, the problem of fuel economy arises.

The Fuel Research Board of the Ingeniörsvetenskapsakademien (Swedish Institute for Scientific-Industrial Research) has made a thorough investigation of furnaces of semi-producer type, which are commonly used for firing sawdust and waste wood. It has been found that in most cases the working conditions of the furnaces could be much improved. In particular, it is to be recommended that continuous charging, a fuel not too moist, and a sufficient supply of secondary air be used. It was ascertained that with a high percentage of moisture in the fuel, 50 per cent. or more, almost complete combustion takes place in the furnace, so that the gas produced by it is hardly combustible. For such moist sawdust a better type of furnace must be found, and just now a furnace with stepped grate is being installed in a sawmill for trial. Improved efficiency is also to be gained by drying the fuel and pre-heating the combustion air. Even the limited reduction of the moisture that can be effected by using the waste gases of the boiler for drying is of good service. The drying is sometimes made in drying towers, where the hot flue gases pass horizontally through a vertical fuel column, sometimes in chambers, where the gases are led through perforated wagons containing the fuel. Experiments carried out with rotary drums, in which the hot gases and the fuel are intimately mixed, have also proved the possibilities of using driers of this design. At all events, precautions must be taken that the fuel does not catch fire as it comes into contact with the hot gases.

The main industries of this type in Sweden employing heating steam are the paper mills and the cellulose mills. The sugar works and refineries, the breweries and the match factories, can also be counted among these. The other industries belonging to this group are of very small account in the power market.

The match-factories have a particular position, inasmuch as their own waste wood suffices for the generation of the needed heating steam, and out of this steam a sufficient quantity, or rather a surplus, of power can be generated by back-pressure steam engines or turbines.

The cellulose mills need a very great quantity of steam for digesting and drying purposes, and they are important power consumers. With the boiler pressure at present used, their power demand cannot be completely filled by back-pressure turbines, and water power has been introduced. This co-operation between back-pressure turbines and hydro-electrical plants has given rise to a great many interesting regulating problems. The steam flowing through the turbine is regulated by the back pressure, which thus is held constant. The turbine then delivers the exact quantity of low-pressure heating steam needed in the mill. To the bus-bars all the energy is delivered that the turbine can generate out of this steam. As the three-phase generator of the turbine is connected to the transmisson lines from the distant water-power station, the speed of the turbine is kept constant by the speed governors in the water-power plant. If the speed of the turbine exceeds the normal value by, for instance, only 5 per cent., its governor begins to throttle down. When this occurs the back-pressure tends to drop and the balance of low-pressure steam needed is by-passed direct from the boilers through a reducing valve.

In the paper mills various combinations are used. In a certain mill the reciprocating steam engines for driving the variable part of the paper-making machines are retained. The heating steam needed, in addition to the exhaust steam of these engines, flows through a back-pressure turbine to the common low-pressure pipe In another mill the whole amount of heating steam passes through a back-pressure turbine, driving a three-phase generator connected with the bus-bars. The paper-making machines are driven by direct-current motors fed through Ward-Leonard converters. Another mill, again, has the back-pressure turbine coupled to one three-phase generator and to two direct-current generators of different voltage. The direct-current motors of the paper-making machines can thus work with three different tensions and thereby obtain a wide range of speed regulation. The three-phase generator is connected with the water-power station and works as a generator or as a synchronous motor, according to circumstances.

On the whole, efforts are made to build and instal back-pressure engines and turbines with the lowest possible steam-consumption per kw.h., the highest possible yield of power from a given quantity of heating steam being thus obtained. The efforts to build boilers for very high pressures also aim at the same result. It may be worth mentioning that an "Atmos-boiler," constructed for a pressure of 60 atmospheres (850 lb.), has been working in a sugar refinery in Gothenburg since the end of 1921, feeding a back-pressure turbine for 50 atmospheres admission pressure (700 lb.). A new boiler of the same make with a pressure of 100 atmospheres (1,400 lb.) was put into service in October, 1923.

Many industries consuming heating steam have found it profitable to instal Ruths' steam accumulators in order to smooth the load curve of the boilers, thus increasing their economy and facilitating their operation. This accumulator also increases the power that can be obtained from the back-pressure turbine, as the steam flow through the turbine will be constant. It may here be mentioned that the firm of A. B. Vaporackumulator, Stockholm, has in an excellent way solved the problem of building reliable reducing valves by equipping them with sensitive oil relay governors.

In the year 1921 there was a total amount of 166,000 steam horse-power installed in electric power stations built for distribution purposes.

The great stations in Västeras and a couple of the medium-sized stations have for the most part to work only during water shortage. But all the others, lying as they do in towns or in industrial centres, have three different purposes: (1) To act as stand-by during water shortage; (2) to act as stand-by for disturbances in the transmission system; (3) to take the local peak loads off the water-power stations and the transmission lines.

All these stations work with a very low load factor, but nevertheless it has generally been found profitable to equip them with boilers and turbines of the most economical design.

The experience of the author, who has planned, or co-operated in the planning, of many of the medium-sized plants, is that such must be built with special consideration for the necessity of being run by as small an experienced permanent staff as possible.

The purpose of these stations to take the peak loads and to act as stand-by plants in case of disturbances makes rapid starting indispensable. It is usually the time necessary to get the boilers under steam that settles the length of time required for the starting of the station. This time can, of course, be materially reduced if the boilers are continuously kept under pressure. With the Stockholm plant this is accomplished with the aid of an electrically heated boiler of 2,000 kw. capacity, fed with water power during periods of sufficient water supply. Other stations, too, have adopted the same arrangement or keep one boiler under steam in order to keep them all warm. Oil burners are also often installed in order to accelerate the starting-up process of the boilers.

At two plants, recently built in Malmö and in Halmstad, the time for starting the station has been still more reduced by installing Ruths' steam accumulators. The turbine can be run at full load with steam from the accumulator until the boilers are heated up to overtake the load. The accumulator, when loaded, is always ready to supply immediately. At these plants it is, thus, the turbine that settles the length of time necessary for starting the station.

At Malmö this time is about three minutes plus the time necessary for synchronising. At the official trials a turbine of 3,750 kw., starting cold but with a vacuum in the condenser, was fully loaded in 6¼ minutes after starting. The vacuum is maintained by a small 10-h.p. condensing machine that is always running.

At Halmstad a turbine of 800 kw. was, on some trials, started cold, in 18 seconds, with the condenser machinery running, and was fully loaded in 120 seconds after starting.

These turbines, manufactured by A. B. de Lavals Angturbin, Stockholm, work with a normal admission pressure of 13 to 14 atmospheres (185 to 200 lb.), but when using steam from the accumulator they can give full load at a pressure of 1·5 atmospheres (22 lb.). This is made possible by a series of by-passes, automatically governed. The steam economy of the turbines, working with normal boiler pressure, is nevertheless almost unimpaired.

If the generating set is kept running by water power with the alternator used as a synchronous motor for improvement of the power factor, the set, with the aid of the accumulator, automatically takes over the load if the transmission line breaks down.

* Paper, abridged, contributed to Section D of the World Power Conference on July 3, 1924.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the communicators are given in italics.

Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 1s.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

ELECTRICAL APPARATUS.

214,338. A. H. S. MacCallum, Caversham. Transformers. (5 *Figs.*) January 22, 1923.—The invention relates to a transformer for use in high frequency circuits, such as wireless telegraph receiving and transmitting circuits, in which mutual induction between the windings is varied by movement of a conducting shield in their mutual field. The transformer is a disc transformer of the plug-in type. 1, 2 are the coils wound concentrically on a flat bobbin which is formed in two parts 3, 4. 5 is the block carrying the pins 6 of the plug. A straight rod 7 passes through central holes in the parts 3, 4 of the bobbin and is screwed into a central hole in the block 5. The parts are clamped together by a nut 8. A shielding member comprising a disc of copper 9 is mounted on a carrier 10 consisting

Fig. 1.

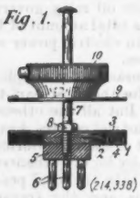


Fig. 2.

of a block of ebonite, and both the disc and the carrier are slidably and centrally mounted on the rod 7. A hole 11 is formed in the carrier 10 from the outer edge and does not extend completely therethrough; in the hole is mounted a slidable bar 12. The hole 11 is so disposed that the bar 12 is to one side of the rod 7 and the bar 12 has at the side adjacent the rod a notch or depression 13 with a sloping surface 14. A spring 15 at the bottom of the hole 11 acts on the end of the bar 12 to cause the sloping surface 14 to engage the rod 7 and grip it. The end of the bar 12 projects from the edge of the carrier so that by depressing it the sloping surface 14 may be released from engagement with the rod and the shielding member be rendered free to be moved thereon. (*Sealed.*)

214,698. J. E. Calverley, Ribbleton, Preston, and W. E. Highfield, Westminster, London. Commutators. (2 *Figs.*) January 16, 1923.—The invention relates to commutators of electric machines of the kind which are formed as units structurally separate from the rest of the machine and in which the segments are held in place by means of a moulded composition. The improvements, in accordance with the invention, apply to

Fig. 1.

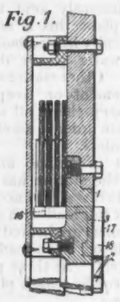
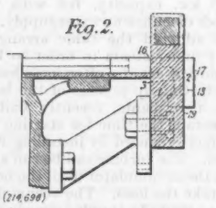


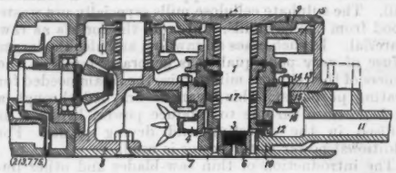
Fig. 2.



commutators in the form of discs, either flat or slightly conical, of the stationary or rotating type. 1 is a disc of moulded composition and 2 segments provided with undercut recesses 3 and consisting of limbs 18 projecting from the face 19 of the disc 1 to form working faces 17 and limbs 16 extending from the back of the disc 1 for the purpose of forming connections. (*Sealed.*)

MINING, METALLURGY AND METAL WORKING.

213,775. W. A. Logan, Bradford. Coal-cutting Machines. (1 *Fig.*) April 14, 1923.—The invention relates to coal-cutting machines of the chain-cutter type, and aims, *inter alia*, at securing a more rigid mounting of the gear case containing the gearing for the cutter-chain drive. The invention consists broadly in the feature that the non-rotary shaft constituting the mounting for the cutter-chain driving sprocket wheel and the main reduction spur wheel is formed as a bolt serving rigidly to bind together the cover and the bottom plate of the gear case. A secondary characteristic of the invention consists in the feature that the bifurcations of the jib are mounted so that they can revolve on journals located, respectively, on the bottom plate and on an intermediate web of the gear case, with which journals are associated flanges serving, in conjunction with the bifurcations, to tie the web and the bottom plate together. There is substituted for the usual rotary vertical shaft carrying the cutter-chain sprocket wheel a non-rotary shaft 1 formed as a bolt having a head 2 and a screw-threaded end 3. Revolvably mounted on the shaft 1 are the sprocket wheel 4 and the main reduction spur wheel 5. The lower end 3 of the shaft 1 is threaded into a ring 6 bolted to the bottom plate 7, to which bottom plate a ledge 8 on a depending extension of the gear case is also bolted. The head 2 is let into the cover 9 of the gear case. The shaft 1 thus serves as a rigid member binding together the cover of the gear case and the bottom plate. The ring 6 constitutes a journal for the lower bifurcation 10 of the jib 11, and presents, at the upper end, an out-turned flange 12 which engages over the bifurcation 10. Formed on the intermediate web 13 of the gear case is a boss 14 presenting a journal for the upper



bifurcation 15 of the jib 11 and associated with a flange ring 16 which engages under the bifurcation 15. The bifurcations 10, 15 thus serve to tie together the web 13 and the plate 7. The chain-driving sprocket wheel 4 is carried by a bearing 17 surrounding the lower end of the shaft 1 and is clear of the gear case proper. (*Sealed.*)

213,999. Travers and Clark, Limited, Manchester, M. W. Travers, Manchester, and F. W. Clark, Manchester. Furnaces. (2 *Figs.*) January 15, 1923.—The invention relates to furnaces and especially to glass-pot furnaces. According to the invention, an air duct has a number of ports communicating with an annular chamber formed round the refractory shell of the producer or combustion space, and having a number of

Fig. 1.

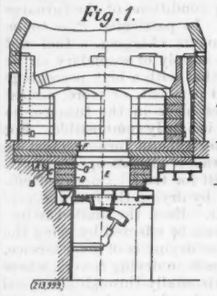
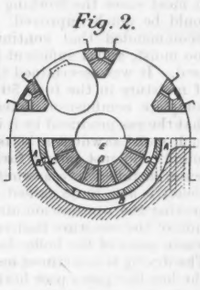


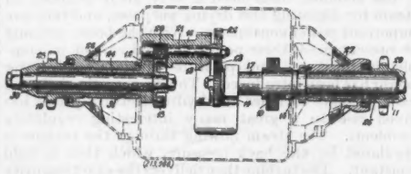
Fig. 2.



passages by which the air can pass from the chamber to the producer or combustion space. A is the air duct into which air can be forced by any convenient mechanism. In this duct, a number of ports B is formed by which the air passes into an annular chamber C surrounding the refractory shell D of the producer E. In the shell and close beneath the siege blocks F is formed a number of passages from the chamber C into the producer E. (*Sealed.*)

MOTOR ROAD VEHICLES.

213,988. S. E. Alley, Westminster, London, and G. Woodvine, Shrewsbury. Combined Engine Crankshaft and Differential Driving Gearing. (1 *Fig.*) January 11, 1923.—The invention relates to combined engine crankshaft and differential driving gearing. The mechanism comprises aligned end shafts 10, 11, whereof the axis is the crankshaft axis. The crank webs are shown at 12, 13, 14 and 15 and the crank-pins at 16, 17. The shafts 10, 11 carry, at the inner faces of the webs 12, 15, gear wheels 18, 19 which mesh with corresponding wheels 20 carried on shafts 21 co-axial with the crank-pins 16, 17. The wheels 20 are rotatable bodily with the crank-pins about the crankshaft axis. The shafts 21 also carry other wheels 22, 23 which mesh with each other and constitute part of the differential gearing. On the outer faces of the webs 12, 15



are sleeves 24, 25 which are fixed with their respective webs. The sleeves 24, 25 constitute the sole bearing for the end shafts 10, 11. Bushes 30, 31 support the ends of the sleeve 24. The sleeves 24, 25 are themselves supported in bearings constituted by portions 26, 27 of the casing of the gearing. The sleeves extend at least to points at, or substantially at, the outer ends of the bearings 26, 27 and thus the wear in the latter will be constant along their length. Actually the sleeves are prolonged beyond the ends of the bearings 26, 27 and enveloped by, and form the bearings for, hollow sprocket wheels 28, 29 fixed to the end shafts 10, 11, respectively. These sprocket wheels may be regarded as affording the principal support for the outer ends of the shafts 10, 11 and consequently it will not be of importance if the bushes 30 become worn or are omitted. (*Sealed.*)

213,990. The Associated Equipment Company, Limited, Westminster, London, and H. K. Thomas, Westminster, London. Steering and Controlling Road Vehicles. (2 *Figs.*) January 12, 1923.—The invention relates to the steering and controlling of road vehicles of the type in which the vehicle is a compound vehicle comprising two or more portions, each portion with its own road wheels, which portions are attached together by a connection providing a vertical axis about which the two portions can turn relatively to each other for steering the vehicle. According to the primary feature of the invention, there is provided a vehicle of the type described which is characterised by the combination with the said connection, of means, operable at will (for example when the vehicle is to be driven backwards), for locking the vehicle portions against relative movement about the said axis. Thus, when the vehicle is travelling backwards, its two portions can be maintained locked in any desired relationship to each other and consequently the whole vehicle will be under adequate control by the driver. There is shown at 10 the rear portion of a tractor vehicle part, and at 11 the front portion of a trailer vehicle part. The tractor carries a turntable 12 having an upstanding central pivot pin 13 around which a sleeve 14 on the trailer 11 centres itself. The turntable 12 carries an annular bearing ring 15 which receives against it a corresponding bearing ring 16 on the under part of the trailer. The rings 15 and 16 are concentric about the axis of the pin 13. Carried upon the trailer 11 is a toothed rack 17 which is concentric with the axis of the pin 13 and is movable thereabout with the trailer. This rack 17 has blind ends 18 and 19, and co-operating with the rack is a toothed wheel 20 rotatably mounted upon the turntable 12, and therefore upon the tractor 10. The effect of the plain portions 18 and 19 at the ends of the toothed part of the rack 17 is to prevent the relative travel clear of the rack of the wheel 20. It will be understood that the axis of the wheel 20 is at a fixed distance from the axis of the pin 13, and consequently when the two parts of the vehicle move relatively to each other the wheel 20 will be rotated by the rack until one end or the other of the rack is reached. When this occurs, further rotation of the wheel 20 will be prevented and, consequently, further movement

Fig. 1.

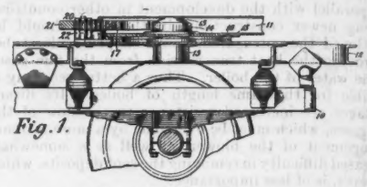
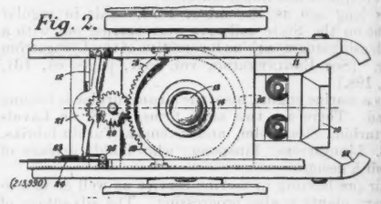


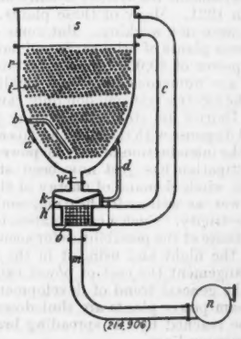
Fig. 2.



in the same direction of the two portions of the vehicle relatively to each other will be prevented. Therefore excessive movement of the two parts of the vehicle will be impossible. A further toothed member 21 is also provided, which, at one end, is pivoted in a bearing 22 on the turntable 12. At the other end, the member 21 is controlled by a spring 23 which tends to draw the member 21 away from the wheel 20, and a flexible connection 24 passing over a pulley 25 leads from the member 21 to a point adjacent the seat of the driver of the vehicle. By operating the connection 24, the driver can move the member 21 into engagement with the wheel 20 and prevent rotation of the latter about its own axis. It will be appreciated that when the locking member 21 is in unlocking position, *i.e.*, as shown in the drawings, the rack 17 will be free to move and will do so as the vehicle is steered. Naturally its movement will rotate the wheel 21 about the axis of the latter. When the vehicle is to travel backwards, the driver having manœuvred the two portions so that they are at the requisite angle to each other, will release the locking member 21 and permit it to move into engagement with the wheel 20, thereby preventing further rotation of the latter and locking the two vehicle parts in their chosen angular relationship. (*Sealed.*)

STEAM ENGINES, BOILERS, EVAPORATORS, &c.

214,906. G. and J. Weir, Limited, Cathcart, Glasgow, and J. G. Weir, Cathcart, Glasgow. Steam Condensers. (1 *Fig.*) September 10, 1924.—The invention relates to steam condensers of the surface type. According to the invention, the condensate is passed, on leaving the condenser, into a feed-water heater, and a portion of the exhaust steam—uncooled by contact with the cooling surface in the condenser—is led to the heater, the steam and the condensate being brought into intimate contact with each other in the heater so that feed water is withdrawn from the heater and passed into the feed system at a relatively high temperature. *r* is the condenser and *t* the tubes through which passes the condensing water. The inlet for exhaust steam is at *s* and *a* is the air withdrawal port. This port is placed behind a baffle *b*. *w* is the water-withdrawal



port whereby the condensate flows from the condenser into the heater *h*. The steam is led to the heater by the conduit *c* from the top of the condenser above the uppermost row of tubes. The steam from the conduit *c* is admitted to the heater *h* through the perforations *o*, and the condensate is sprayed into the heater through the perforated plate *k*; the water, mingling with the steam, becomes heated thereby, and the heated water is withdrawn through the pipe *m* by the pump *n*. *d* is a pipe leading from the heater to the condenser. Through this pipe air, separated from the steam in the heater by the action of the water, is withdrawn to the condenser. The pipe *d* is led to the side of the condenser other than that containing the air-withdrawal port *a*. This is to insure that the air withdrawn through the pipe *d* (which is relatively hot) will pass over relatively cold surfaces before gaining access to the port *a*. (*Sealed.*)